HAWAII AGRICULTURAL EXPERIMENT STATION

REPORT

1939

HAWAII AGRICULTURAL EXPERIMENT STATION
of the
University of Hawaii

D. L. Crawford, LL.D., President, University of Hawaii
J. H. Beaumont, Ph.D., Director

Station Staff as of June 30, 1939

Administration
L. A. Henke, M.S. ..... Assistant Director
H. K. Hee ..... Junior Administrative Assistant

Agronomy
J. C. Ripperton, M.S. ..... Agronomist
E. Y. Hosaka, M.S. ..... Collaborator
M. Takahashi, M.S. ..... Junior Agronomist
T. Togashi, B.S. ..... Assistant in Agronomy
R. A. Lyman, B.S. ..... Assistant in Agronomy

Animal Husbandry
L. A. Henke, M.S. ..... Animal Husbandman
S. H. Work, Ph.D. ..... Associate Animal Husbandman
C. I. Maruyama, B.S. ..... Assistant in Animal Husbandry

Chemistry and Soils
L. A. Dean, Ph.D. ..... Associate Chemist
J. B. Bartlett, Ph.D. ..... Junior Chemist
E. T. Fukunaga, M.S. ..... Assistant in Chemistry
Ruth Yoshida, M.A. ..... Assistant in Chemistry

Entomology
F. G. Holdaway, Ph.D. ..... Entomologist

Horticulture
J. H. Beaumont, Ph.D. ..... Horticulturist
W. W. Jones, Ph.D. ..... Assistant Horticulturist
J. E. Welch, M. S. ..... Assistant Olericulturist
[1]W. B. Storey, M.S. ..... Junior Pomologist
H. D. Michener, Ph.D. ..... Research Fellow
P. L. Guest, M.S. ..... Assistant in Horticulture
Marguerite E. Hartung, B.A. ..... Assistant in Horticulture
Hisashi Kubota, M.S. ..... Assistant in Horticulture
Dick Sumida, B.S. ..... Assistant in Horticulture
J. Holzman, M.S. ..... Assistant in Horticulture

Irrigation
H. A. Wadsworth, B.S. ..... Irrigation Engineer

Nutrition
Carey D. Miller, M.S. ..... Nutritionist
C. J. Hamre, Ph.D. ..... Histologist
Martha Potgieter, Ph.D. ..... Associate Nutritionist
Lucille Louis, B.S. ..... Assistant in Nutrition
Toyo Takase, B.S. ..... Assistant in Nutrition

Parasitology
J. E. Alicata, Ph.D. ..... Parasitologist

Plant Pathology
G. K. Parris, Ph.D. ..... Plant Pathologist
K. Kikuta, B.S. ..... Assistant in Plant Pathology

Plant Physiology
H. F. Clements, Ph.D. ..... Plant Physiologist
E. K. Akamine, B.S. ..... Assistant in Plant Physiology
H. G. Heggeness, M.S. ..... Graduate Assistant

Poultry Husbandry
C. M. Bice, B.S. ..... Poultry Husbandman

Publications
Kathleen W. Pierson, B.A. ..... Assistant Editor

Branch Stations
R. K. Pahau, B.S. ..... Superintendent, Kona Branch Station
F. T. Murphy, B.S. ..... Superintendent, Haleakala Branch Station
M. L. McDougal ..... Foreman, Poamoho Farm

[1] Absent on leave.

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION

1939

Issued March 1940

Published by the
UNIVERSITY OF HAWAII
Honolulu, T. H.

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Introduction

The Hawaii Agricultural Experiment Station, on June 30, 1939, completed its first year as a purely Territorial institution, under the authority of the University of Hawaii. The purposes and objectives of the present station parallel those of the experiment stations of the several states, the laws and regulations governing it are the same, and the Federal funds received are in equivalent amounts, with the exception of the Purnell research grant. The latter is still being increased, although not at the rate specified in the Hawaii Act of 1928.

With the virtual expenditure of sugar-processing-tax funds, the station operated on a much smaller budget than in the preceding 3 years, and curtailed operations and a reduced staff were necessary. It is gratifying, however, that the nucleus of the excellent research staff remains and, with increased facilities, should continue important investigations with significant contributions in the future.

Increased Facilities

A new wing to the agricultural building, completed in May, provides research laboratories and office space for the departments of chemistry and soils, soil physics, plant physiology, plant pathology, entomology, olericulture, pomology, and human nutrition.

A new greenhouse adds to the existing facilities for research in soils, plant physiology, plant pathology, and entomology.

Improvements in the dairy consist of a pasteurizer and an addition to the refrigeration plant.

A superintendent's cottage and a fresh water system were constructed at Poamoho Farm: the buildings and equipment at the Kona and Haleakala Branch Stations were also improved.

The agronomy and a portion of the horticultural offices and laboratories remain at Pensacola and Prospect Streets, on Federal property. The station may be deprived of the use of these lands and buildings at any time and will be forced to replace the facilities.

Changes in Personnel

The last annual report recorded the resignation of Dr. O. C. Magistad as director. On October 1, 1938, President Crawford and

the regents of the University appointed Dr. J. H. Beaumont, horticulturist, as his successor.

During the year a department of plant physiology was formed, with Dr. H. F. Clements appointed plant physiologist and H. G. Heggeness a graduate assistant. E. K. Akamine was transferred from the agronomy division to a position as assistant in plant physiology.

Mr. William B. Storey, junior pomologist, took leave from September 1938; during his absence Dr. H. D. Michener is serving as a research fellow. A. W. Burt, superintendent of the Haleakala Branch Station resigned in July, and his position was taken by F. T. Murphy.

Other separations from the research staff during the year included J. H. Payne, associate chemist, H. J. Spencer, assistant biologist, G. W. H. Goo, junior parasitologist, Ellen Chang, assistant in parasitology, and Amy Suehiro, assistant in entomology. Additional new employees were J. B. Bartlett, junior chemist, and J. J. Holzman, assistant in horticulture.

Research Program and Accomplishments

The program of the experiment station includes research on fundamental and far-reaching scientific problems as well as on questions of more immediate practical value. Among the former may be mentioned investigations of the chemical and physical properties of Hawaiian soils, determination of the mineral and vitamin contents of locally grown food crops, identification of diseases and insects affecting various plants, and genetic and physiological studies; the latter group includes such projects as sterilization and storage of fruits and vegetables, treatment of cattle and poultry for parasites, and determination of the animal-feed value of various local by-products.

Some of the more significant projects of research in the various departments include:

Agronomy. Introduction of forage and pasture species from tropical and sub-tropical countries; determining adaptability and growth characteristics of the introductions at four localities; testing desirable species for palatability and forage value; and an ecological survey of distribution of grasses and shrubs throughout the Territory, with a classification of agricultural lands into climatic zones.

Animal Husbandry. Test of papaya and avocado as feeds for swine; use of yeast from cane molasses as protein supplement for swine; and a pilot test on the value of urea as a substitute for protein in dairy rations.

Chemistry and Soils. Determination of the form and availability of phosphorus in Hawaiian soils; and a study of the factors affecting rate of mineralization of organic nitrogen in the soil, and consequent availability of the element to plants.

Entomology. Identification and study of life habits of insect pests of truck and fruit crops; search for parasites of the cabbage worm; and determination of habits and effects of the tomato bug.

Horticulture. Effects on the papaya of heat sterilization treatment to permit shipment of fruits to the mainland; a study of oil formation and storage in the macadamia, as they affect cultural practices; measurement of macadamias during three seasons to determine susceptibility to seasonal variations; treatment of litchi cuttings with indole acetic acid to promote rooting of cuttings; use of ethylene chlorohydrin to induce earlier germination of seed potatoes; and selection of rust-resistant green beans, large firm-headed lettuce varieties, and cauliflower with good heading characteristics.

Nutrition. Determination of the composition and food value of 12 common and 3 Filipino vegetables grown in Hawaii; establishment of curves of response for biological determinations of vitamins; study of the diets of 56 independent farmer-families in Hawaii; and a survey of hemoglobin and blood-cell values of preschool children and young men and women in Hawaii.

Parasitology. Continued work with Distol and kamala in treatment of cattle with liver fluke; exposition of the life cycles of the parasites of poultry, *Subulura brumpti* and *Postharmostomum gallinum*; collection of parasites infecting local horses; and a study of effects of nutrition of poultry on resistance to parasitism.

Plant Pathology. Greenhouse studies of the strains of bean rust present in the Territory; mechanical transmission of a disease of papaya, believed to be virus in origin; and proof that one of the most serious diseases of tomato is caused by the yellow spot of pineapple virus.

Plant Physiology. Study of the factors affecting germination of the seed pieces of sugarcane; determination of the arsenic tolerance

of Sudan grass, tomato, and bush bean; and treatment of seeds with various substances to increase germination.

Poultry. Breeding of chickens in wire-floored houses for reduction of parasitic and other diseases; vaccination of day-old chicks against fowl pox; and a study of the rates of gain, feed consumption, and costs of production of New Hampshire chickens.

Publications. The annual report and 4 bulletins have been released by the station during the year. In addition 16 technical papers and 13 popular articles have been published in various journals.

Agronomy

Pasture Investigations

Pasture Survey

The ecological approach to the study of land utilization, used widely elsewhere, should be of especial value in a program of diversified agriculture for Hawaii. Further study of the distribution of plant species shows that the climatic zones (previously described) are not entirely adequate. Subdivision of certain of the zones on the basis of altitude leads to greater conformity with distribution of both wild plants and cultivated species. There are indications also that insect pests and diseases of crops may well be studied by climatic zones. Investigations in the field demonstrate the desirability of this method of classifying desirable pasture species as well as important plant pests according to their zonal distribution.

Both native and introduced species of grasses and shrubs, well adapted to specific zones, may spread rapidly at the expense of more desirable but less acclimated plants. Familiar examples of

FIGURE 1.—Mechanical eradication makes possible rapid and economical clearing of plant pests before planting waste land to pasture

TABLE 1.—Principal plant pests of Hawaiian pastures and their zonal distribution

Names of plant pests	Climatic requirements		Distribution		Remarks
	Zone [1]	Altitude	Location	Relative area	
		Feet			
Shrubs					
Dodonaea viscosa (aalii)	B, C	2,000 to 5,000	All islands	Moderate	Native species; easily eradicated
Emex spinosa (emex)	B, C	500 to 3,000	Hawaii, Molokai	Very small	Recent introduction; a very unpalatable prostrate shrub which chokes out all other growth
Eupatorium adenophorum (pamakani)	C, D	1,500 to 4,000	Maui, Molokai, Oahu	Moderate	Recent introduction; a serious pest which is spreading rapidly
Lantana camara (lantana)	B	0 to 3,000	All islands	Large	Naturalized species; easily eradicated
Melastoma decemfidium (melastoma)	E	500 to 1,500	Kauai	Small	Recent introduction; a serious pest but thus far restricted to one locality
Myrica faya (firebush)	E	3,000	Hawaii	do	Recent introduction; a large shrub of very local distribution but a serious potential pest
Opuntia megacantha (cactus)	B	0 to 2,000	All islands	Moderate	Naturalized species; spreading slowly but serious in a few localities
Psidium guajava (guava)	E	0 to 3,000	do	Very large	Naturalized species; a large shrub probably the most serious pest from standpoint of distribution and value of land covered
Schinus terrabentifolius (Hawaiian holly)	B	0 to 2,000	do	Small	A large shrub, introduced as an ornamental which has escaped into the ranges and is spreading rapidly; a serious potential pest

TABLE 1.—Principal plant pests of Hawaiian pastures and their zonal distribution (continued)

Names of plant pests	Climatic requirements		Distribution		Remarks
	Zone [1]	Altitude	Location	Relative area	
Stachytarpheta dichotoma (joee)	C	1,000 to 3,000	All islands	Moderate	Naturalized species; a small shrub, dense in a few localities, in open stands in most places
Styphelia tameiameiae (puakeawe)	C, D	3,000 to 5,000	Hawaii, Maui, Kauai	do	Native species easily eradicated
Triumfetta bartramia (Sacramento burr)	B, C	1,000 to 3,000	Maui	Small	Recent introduction; has some forage value but forms dense thickets and spreads rapidly
Ulex europaeus (gorse)	C	3,000	do	Very small	Introduced species; grows in dense thickets with very spiny leaves but nearly eradicated
Grasses					
Cymbopogon refractus (barbwire grass)	B	1,000 to 2,000	Hawaii, Maui	Very small	Recent introduction; an undesirable, tough wiry-leaved grass
Pennisetum ruppelii (fountain grass)	B	1,500 to 3,000	Hawaii	Small	Recent introduction; a harsh, wiry-leaved grass, restricted thus far to rocky areas
Trichachne insularis (sour grass)	A, B, C	0 to 1,000	Oahu	Small	Recent introduction; very unpalatable to stock but spreading rapidly

[1]Exact definitions of the zones cannot be given in terms of rainfall and altitude since they vary with location. The following are approximations: *A*, Low-lying areas bordering leeward coast line, very hot, with very low rainfall (less than 20 inches); *B*, principally leeward zone just above *A*, hot, with low rainfall (20 to 40 inches); *C*, low to moderate altitudes, with moderate temperature and moderate rainfall (40 to 65 inches); *D*, usually above 4,000 feet, found only on Hawaii and Maui, cold, with moderate rainfall (40 to 65 inches); *E*, chiefly the windward slopes, with moderate to cool temperatures and high rainfall (65 inches and above).

such pests are lantana (*Lantana camara*) and guava (*Psidium guajava*). Large sections of permanent pasture land have been rendered practically useless by this encroachment, and the reclamation of land for other agricultural purposes necessitates eradication of the too-persistent species. Table 1 lists the principal plant pests of the Territory, as indicated by a pasture survey. Weeds of cultivated fields are not included.

Numerous factors enter into the determination of vegetation which will be successful in a particular location. These include the various aspects of climate, soil, competition with other plants, and pasture management. Under Hawaiian conditions, the distribution of wild plants and ranch experience with planted species both indicate that the climatic factors are most important. Table 2 lists a number of the desirable grasses and legumes, to serve as a general planting guide, with information as to zonal distribution and other growth conditions. (Ripperton, Hosaka)

Introduction and Testing of Forage Plants

New forage-plant accessions during the year totaled 182 grasses, 74 legumes, and 24 shrubs. In the introduction of species, the special needs of the Territory are being given consideration:

(1) *Soilage crops for dairies.* Perennial, high-yielding fodder grasses are desirable for dairy cattle. *Pennisetum purpureum* (Napier grass), one of the leaders in this class, tends to produce forage of low protein content and a large proportion of stem, and is adapted only to the lower levels. *Sorghum vulgare sudanense* (Sudan grass), although highly palatable, is now little grown because of its susceptibility to rust and its relatively poor ratoon crops.

In addition to extensive experiments with Napier grass strains and cultural methods, four Sudan grass selections from Texas are under trial. One is said to be resistant to rust; another, a cross with a forage sorghum, has a sweet sap.

Leguminous crops adapted to periodic cutting are needed to replace large shipments of mainland alfalfa, hay, and concentrated feeds. *Leucaena glauca* (koa haole) and *Desmanthus virgatus* appear to be suitable for this purpose; recent introductions of promise are *Stylosanthes guyanensis* (trifolio) and several species of *Desmodium—discolor, tortuosum, barbata,* and *pabularis.*

TABLE 2.—Desirable forage grasses and legumes, and their zonal distribution

Names of plants	Climatic requirements		Remarks
	Zone[1]	Altitude	
		Feet	
Grasses			
Agrostis alba (redtop)	E	2,000 to 5,000	Excellent for cool, foggy areas; other species of the bentgrasses would probably also be adapted
Andropogon barbinodis (fuzzy top)	B, C	0 to 3,000	Grows in dry, rocky places; several other dryland members of this genus are valuable, as *A. sericeus* and *A. scoparius*
Bromus catharticus (rescue grass)	C	2,000 to 5,000	Principally an annual; *B. inermis*, a fine grass on the mainland of the United States, is being tested
Chloris gayana (Rhodes grass)	B, C, E	0 to 3,000	A hardy grass but only fair in palatability
Cynodon dactylon (Bermuda grass—giant strain)	B, C, E	0 to 3,000	Larger and more palatable than the common strain of Bermuda grass; a recent introduction, *C. plectostachyum* is worthy of trial in Zone E
Dactylis glomerata (orchard grass)	C, D, E	3,000 to 6,000	One of the best of the temperate-zone species in Hawaii; many strains are available and should be tested before selection
Digitaria henryi (Henry's crabgrass)	C, E	0 to 2,000	Most useful in the moist grass sections; other desirable, less-known species are *D. pentzii* and *D. milanjiana*
Holcus lanatus (velvet grass, Yorkshire fog)	D, E	4,000 to 6,000	Most useful in high, cool areas where water for stock is not available, due to its ability to collect and hold dew on its hairy leaves
Lolium multiflorum (Italian ryegrass)	C, D, E	4,000 to 6,000	While this species has the widest distribution, other useful ryegrasses are *L. perenne*, *L. subulatum*, and *L. westerwoldicum*
Melinis minutiflora (molasses grass)	B, C, E	0 to 3,500	Makes a vigorous growth the first crop but requires rotational grazing to persist

TABLE 2.—Desirable forage grasses and legumes, and their zonal distribution (continued)

Names of plants	Climatic requirements		Remarks
	Altitude	Zone [1]	
		Feet	
Microlaena stipoides (meadow ricegrass)	D, E	3,000 to 5,000	An aggressive species under cool, foggy, or shaded conditions
Panicum maximum (guinea grass)	B, C, E	0 to 2,500	Particularly valuable for dry, lowland ranges; a number of strains are available
Panicum purpurascens (Para grass)	C, E	0 to 2,000	Of value both for grazing and as cut forage; a number of promising recently introduced panic grasses are under trial
Paspalum dilatatum (Dallas grass)	C, E	0 to 5,000	One of the best of the introduced species, adapted to a wide altitude range; other desirable species are *P. notatum* and *P. malacophyllum*
Pennisetum clandestinum (kikuyu grass)	C, E	0 to 5,000	Particularly valuable in checking plant pests such as guava and pamakani; not recommended for areas where the better pasture grasses will grow
Pennisetum purpureum (Napier grass)	C, E	0 to 2,500	The heaviest-yielding grass in the; Hawaiian lowlands adapted to grazing as well as cutting
Phalaris tuberosa (large canary grass)	C, E	3,000 to 6,000	An excellent upland grass but difficult to maintain; *P. arundinacea* is valuable under very moist conditions
Poa pratensis (Kentucky bluegrass)	D, E	3,500 to 7,000	Excellent for fertile uplands; *P. compressa* may be found useful for less fertile areas
Tricholaena repens (Natal redtop)	B, C, E	1,000 to 4,000	A hardy grass which spreads rapidly by seed; of secondary grazing value
Legumes			
Desmanthus virgatus	B, C	0 to 1,500	Palatable; spreads rapidly by seed

TABLE 2.—Desirable forage grasses and legumes, and their zonal distribution (continued)

Name of plants	Climatic requirements		Remarks
	Zone [1]	Altitude	
		Feet	
Desmodium uncinatum (Spanish clover)	B, C, E	0 to 4,000	A very adaptable, long-established species of fair palatability; other promising species are *D. discolor and D. tortuosum*
Leucaena glauca (koa haole)	B, C	0 to 1,500	A browse plant of excellent forage value for grazing as well as dairying
Medicago lupulina (black medic)	C	3,000 to 5,000	One of the best of the temperate-zone pasture legumes; burclover (*M. hispida*) has about the same value but extends to lower levels
Melilotus officinalis (yellow sweetclover)	C	2,000 to 4,000	Very seasonal and more inclined than other clovers to cause bloating in cattle
Trifolium repens (white clover)	D, E	3,000 to 6,000	The best clover for cool, moist uplands; many strains are available
Vicia atropurpurea (vetch)	C	3,000 to 5,000	Excellent forage but seasonal and hard to maintain; *V. sativa* and *V. villosa* are also well adapted

[1]Approximate descriptions of climatic zones: *A*, Low-lying areas bordering leeward coast line, very hot, with very low rainfall (less than 20 inches); *B*, principally leeward zone just above *A*, hot, with low rainfall (20 to 40 inches); *C*, low to moderate altitudes, with moderate temperature and moderate rainfall (40 to 65 inches); *D*, usually above 4,000 feet, found only on Hawaii and Maui, cold, with moderate rainfall (40 to 65 inches); *E*, chiefly the windward slopes, with moderate to cool temperatures and high rainfall (65 inches and above).

(2) *Pasture legumes for moist areas at medium altitudes.* The windward areas in Zone E, below 3,000 to 4,000 feet, are devoid of desirable pasture legumes or leguminous shrubs. Fertilization and sound pasture management should extend the temperate-zone legumes, such as *Trifolium repens* (white clover), to lower levels, but it is probable that chief reliance must be placed upon more tropical genera. The *Desmodium* species mentioned above offer promise; *D. uncinatum* (the common Spanish clover) is known to grow on acid, poorly drained soils.

(3) *Dryland grass species.* On many of the leeward areas, forage is sparse and must compete with such pests as lantana and cactus. *Panicum maximum* (guinea grass) is probably the most useful of the available dryland species. Several distinct strains have been secured: a broad-leaved, dark green type known as colonial grass, from Brazil, two types imported from East Africa, and a dwarf type with hairy leaves and a tendency to profuse blooming, from Kauai. These are being compared as to yield and adaptability to climatic zones. (Lyman, Ripperton)

Persistence of Pasture Species Under Grazing

Four paddocks planted to grass and legume mixtures are being grazed in rotation, to determine the persistence of the various species under pasture conditions. Prior to grazing, data were taken on

FIGURE 4.—Grazing experiment: Left, mixtures of promising species competing against each other and volunteers under intermittent grazing; right, making botanical estimates of individual species in a mixture

FIGURE 2.—Promising forage grasses: 1st row, *Andropogon furcatus*; *Paspalum malacophyllum*; 2nd row, *Panicum virgatum*; *Andropogon scoparius*; 3rd row, *Panicum maximum* (two strains); and *Cynodon plectostachyum*

FIGURE 3.—Promising forage legumes: 1st row, *Trifolium repens* (showing response to fertilizers); the same legume, doing well in pastures; 2nd row, *Stylosanthes guyanensis* and *S. mucronata*; *Desmodium discolor*; 3rd row, *Desmanthus virgatus*; and *Desmodium tortuosum*

each plot as to yield of green forage of the four or five major species represented, and stand, vigor, and ground coverage of all species planted. (Ripperton, Lyman)

Comparative Palatability of Forages

A test of the palatability of nine forage grasses was discussed in the 1938 annual report. An excess of a particular grass was stall-fed to a steer, and the relative amount consumed was compared with consumption of Napier grass by the same steer.

Two additional methods of studying palatability have since been inaugurated. By one method, 15 species of grasses and legumes were chopped and placed in racks so that 8 heifers had free access to all forages. The relative amounts of each eaten were determined and expressed as percentages of Napier grass, which is considered very palatable, and Rhodes grass, of only fair palatability.

FIGURE 5.—Grazing cafeteria: Left, general view of 20 species in the cafeteria; right, close-up view, after heavy grazing

The second method consisted of allowing animals to graze in a "grass cafeteria." Relative palatability was determined by recording the order in which the grasses were eaten and the total amount of each consumed.

Such information, properly interpreted, is useful in determining the forage value of a grass and the method of management. (Lyman, Ripperton)

Napier Grass Investigations

A replicated experiment comparing 16 strains of *Pennisetum purpureum* (Napier grass) was established at Poamoho Farm in July 1938. The rate of fertilization has been heavy, totaling 400 pounds of nitrogen, 300 pounds of phosphoric acid, and 300 pounds of potash. To date, four crops have been harvested. Growth has been slower at this location than at University farm, but the yields have steadily increased. With ample plant food and water, the plants have retained green leaves the full length of the stalks, in contrast to the common tendency of mature Napier to consist mainly of stem with dried basal leaves and a tuft of green leaves at the apex. The protein content, on an oven-dry basis, has been maintained at a fairly high level (about 10%) for the first three crops. This is probably due to the heavy nitrogen fertilization and the greater leafage resulting from slow initial growth.

In common with many other strain crosses, a number of the selections show a better tendency to develop viable seed than the standard Napier. Dense stands of new seedlings are often found in these plots. It is possible that, instead of planting crowns or cuttings, a natural spread through seeding may be accomplished in areas too rough to plow or infested with guava. (Ripperton, Takahashi)

Seeding of Pasture Crops

A common practice in Hawaii is the feeding of koa haole seed mixed with molasses to cattle on the range. The defecated seed is said to germinate to a greater extent than untreated seed sown on undisturbed soil. To test this report, each of two animals was fed a 5-pound lot of untreated seed. Of the seeds fed, 58 percent were recovered in the feces; 15 percent consisted of partially digested seeds, black in appearance and abnormally large in size, and the remaining 43 percent were apparently unaffected. The recovered seeds were planted, and germination records indicate that the apparently unaffected seeds reacted in approximately the same manner as fresh seeds, while the partially digested seeds gave evidence of greatly reduced germination. Attempts to secure germination of defecated seed in the feces did not improve the results. Fermentation and a hard crust forming on the surface reduced germination.

Seeds of various leguminous species were inoculated with bacterial cultures secured through the cooperation of Dr. O. N. Allen, bacteriologist at the University, and planted at Poamoho Farm and at the Pensacola and Haleakala Branch Stations. Nodule formation occurred on all species, but no differences were noted in rates of growth of the legumes. Field observations of legumes planted in pastures where the species had not previously grown have shown excellent natural nodulation occurring in a variety of genera. (Lyman)

Field Crop Studies

Sweet Corn

Partially confounded $2 \times 2 \times 2$ fertilizer experiments with U. S. D. A.-34 sweet corn were installed at Poamoho Farm and at Haleakala, the former in March and the latter in May. Treatments consisted of no fertilization (control) and single-element, double-element, and complete fertilization, with nitrogen, phosphoric acid, and potash, each at the basic rate of 100 pounds per acre. Nitrogen fertilization was in two applications, one-half at time of planting and the remainder 6 weeks later; the other constituents were applied at time of planting.

At Poamoho, the effects of treatment were pronounced during the first 6 weeks of growth. All plots receiving phosphorus were exceptionally vigorous—in some parts of the field the corn was two or three times the height of that in the no-phosphate plots. Subsequently growth in the latter accelerated until at maturity the response to phosphorus was not pronounced. Significant increase was found in size of marketable ears but not in number.

The growth to date at Haleakala (2,200 feet altitude) is not more than half that at Poamoho (700 feet) at the same age. This and other trials emphasize the need of breeding strains suited to higher elevations. (Takahashi)

Sweetpotatoes

Another test of five of the station's most promising seedling varieties was made at Poamoho Farm in November 1938 and harvested in May 1939. Yield data on the present test are given in table 3. The seedling varieties did not yield in the same order of

superiority as last year, but their size and shape were excellent. (Takahashi)

TABLE 3.—Comparison of mean yields of sweetpotato varieties grown at Poamoho Farm

Variety	Mean yield per acre [1]	Characteristics
	Tons	
35.14 (seedling variety)	11.49	Medium-long bushy growth; oval tubers with dark yellow flesh, slightly veined
35.9 do	9.51	Long trailing growth; pyriform tubers with yellow flesh
35.23 do	9.39	Medium-long bushy growth; pyriform tubers with dark orange flesh
35.5 do	7.05	Short bushy growth; turnip-shaped tubers with light yellow flesh
Yellow Yam	6.65	Long trailing growth; pyriform tubers with dark orange flesh; tendency to produce many small tubers
Nancy Hall	4.96	Short bushy growth; irregular tubers with numerous ridges and dark orange flesh
35.19 (seedling variety)	3.85	Long trailing viny growth; irregular tubers with light yellow flesh
Difference between means required for significance	2.58	

[1] Mean yield calculated from six plats, each 126 square feet in area.

Taro Variety Test

A test of 10 upland varieties of taro, planted in June 1937 at the Kona Branch Station under randomized block layout, with six replications, was harvested after 15 months of growth. The results are given in table 4.

Since milling data and botanical studies showed that both Iliuaua and Tsurunoko are distinctly different from the Polynesian varieties, and because of their obvious difference in yield, they were not included in the statistical analysis. Among the eight Polynesian varieties, Lehua Maoli significantly outyielded Mana Keokeo, Lehua Palaii, Ulaula Kumu, and Mana Ulu.

Results of a milling test showed considerable variation in the percentages of paiai recovered, ranging from 57.0 percent for Tsurunoko to 83.7 percent for Mana Ulu. These differences would seem to justify a factory practice of purchase of taro on the basis of yield of paiai.

No baking tests were run, but the quality of flour produced from these upland varieties compared favorably in appearance with that produced from wetland varieties previously tested. Flour color ranged from yellow to dark gray, depending primarily on the color of the corm flesh.

The quality of the malted taro product produced was quite different from that produced from the wetland varieties in that it appeared more fibrous and tended to form flocculent masses when made into a beverage. Chemical analyses did not indicate any appreciable difference between the upland and wetland taros as to fiber content. There is a possibility that this difference in behavior might be eliminated by modification of factory technique.

The non-Polynesian varieties, Iliuaua and Tsurunoko, could not be made into the dried taro products since the paiai will not "set." Morphologically, both of these are similar to the Polynesian varieties, but physiologically they are quite distinct. Even among the Polynesian varieties there is a certain amount of difference with regard to desirability for taro products. As a general rule the varieties which are best suited for the making of poi give the best performance in the manufacture of taro products. (Takahashi, Ripperton)

Fertilization of Taro

An experiment at Kona, designed to determine differences in yield of taro due to fertilization, was concluded during the year. The variety Lehua Palaii was used in this test. Yields per acre

TABLE 4.—Yield of taro corms and of flour from upland taro varieties

Variety	Yield of raw taro corms per acre [1]	Recovery of paiai from raw taro	Oven-dry matter in paiai	Recovery of taro flour from raw taro	Yield of taro flour per acre
	Pounds	*Percent*	*Percent*	*Percent*	*Pounds*
Lehua Maoli	33,186	82.1	41.0	33.7	11,180
Eleele Naioea	28,826	80.2	43.1	34.6	9,959
Ohe	28,463	72.9	40.3	29.4	8,365
Lauloa Palakea-eleele	26,785	67.0	38.0	25.4	6,814
Mana Ulu	24,995	83.7	40.5	33.9	8,473
Ulaula Kumu	23,500	72.6	39.6	28.8	6,762
Lehua Palaii	22,920	74.7	42.0	31.4	7,189
Mana Keokeo	22,087	77.9	41.1	32.0	7,066
Iliuaua	58,037 [2]	71.2	28.5	[3]	[3]
Tsurunoko	5,377 [2]	57.0	24.8	[3]	[3]

Difference between mean yields of raw taro corms required for significance—6,620 pounds

[1]Mean yield calculated from six plots each 180 sq. ft. in area.
[2]Deleted from statistical analysis.
[3]Because of the inability of the paiai to "set," no flour was actually produced.

with the various treatments are listed below:

N-K	23.5 tons	N-P-K	21.9 tons
N-P	20.2 tons	2N-P-K	22.8 tons
P-K	21.6 tons	3N-P-K	21.7 tons
	Check 18.8 tons		

Difference required for significance—3.2 tons.

Response to the fertilizers was slight, only the N-K and 2N-P-K treatments significantly outyielding the check plot. This was probably due, in part at least, to the natural fertility of the soil, the check plot yielding 18.8 tons per acre as compared with an estimated average for the Territory of 6 to 10 tons. (Takahashi, Ripperton)

Animal Husbandry

Cattle

Value of Molasses as a Supplement to Napier Grass

In a fourth 12-week, double-reversal experiment with eight cows, Napier grass fed as a roughage was compared with the same grass over which had been poured 4 pounds of cane molasses per cow per day. The cows receiving molasses produced an average of 32.3 pounds of milk per day while those not receiving the supplement produced 31.3 pounds per day. The butterfat content was lower on molasses, however (3.75 percent compared to 3.83 percent). In order to allow for this difference, production was corrected to a 4-percent-fat basis by Gaines' formula, giving 31.1 pounds and 30.5 pounds milk per day for cows when molasses-fed and when not receiving the supplement respectively. The cows averaged 23 pounds additional live weight when cane molasses was fed. In the three previous experiments, cows fed molasses produced slightly more milk and made better gains in weight. (Henke, Maruyama)

Comparison of Rhodes and Sudan Grasses

The second and third experiments comparing Rhodes and Sudan grasses as roughages for dairy cows were completed during the year. Although milk production was higher on the first test when Rhodes grass was fed, the two succeeding tests gave a slight advantage to Sudan grass. The average daily production for the three trials was 35.7 pounds of milk on Sudan grass and 35.0 pounds on Rhodes. Percentages of fat in milk were almost identical, and a difference in live weight occurred in only one trial.

One factor of interest was that consumption of Sudan grass averaged 54 pounds daily, as compared with only 38 pounds of Rhodes grass. This was undoubtedly due in part to the higher moisture content of the former (26.5 percent compared with 22 percent). Total daily nutrient intake per cow from Sudan grass averaged 10.5 pounds, and 9.1 pounds from Rhodes grass. Concentrates consumed were the same for both lots. (Henke, Maruyama)

Soybean- versus Cottonseed-Oil-Cake Meal

Cottonseed-oil-cake meal, although not commonly available in Hawaii, can be secured on special order, and at times the price is lower than that of soybean-oil-cake meal. These two concentrates were compared in a 12-week, double-reversal experiment with eight cows, 60 pounds of each being added to a ration composed of 50 pounds pineapple bran, 50 pounds cane molasses, 6 pounds coconut-oil-cake meal, 30 pounds linseed-oil-cake meal, 2 pounds salt, and 2 pounds steamed bone meal. The amounts of concentrates and of roughage (Napier grass) consumed daily were the same for both lots.

Milk production was slightly lower and butterfat content slightly higher when cottonseed-oil-cake meal was fed, but the differences were not statistically significant. (Henke, Work)

Cane Molasses for Pasture Fattening of Beef Cattle

In a second cooperative experiment at Waianae Ranch, a 60-acre pasture of koa haole was divided into two 30-acre experimental fields, and 12 grade Aberdeen Angus steers were put in each lot for a period of 444 days from May 7, 1937, to July 24, 1938. Steers in one lot received supplementary cane molasses in a trough. Summarized results of the trial appear in table 5.

TABLE 5.—Summarized results of supplementary cane molasses for fattening beef cattle

Pasturage		Lot A Koa haole pasture only	Lot B Koa haole pasture with supplementary cane molasses
Average final weight	(pounds)	934	1,019
Average initial weight	do	563	551
Average total gain	do	371	468[1]
Average daily gain	do	0.84	1.06
Average daily molasses consumption	do	.....	4.89

[1]One steer in this lot died at the end of 112 days, and the figures have been adjusted accordingly.

FIGURE 6.—Steers in second Waianae experiment feeding on broken-down koa haole with seed pods

Average daily gains were lower for steers on both lots than in the previous experiment, and molasses consumption was higher, due probably to two factors—lower rainfall and reduced palatability of the pasturage. In this test rainfall averaged only 0.094 inch per day, less than half the daily rainfall in the first trial. Moreover, the koa haole was so tall that much of the growth was beyond the reach

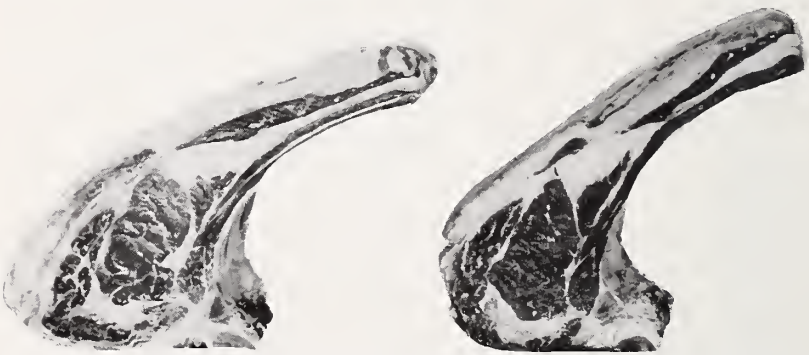

FIGURE 7.—Ninth ribs from steers in second Waianae experiment: Left, from steer receiving molasses in koa haole pasture; right, from steer on koa haole only

of the steers. In the last few weeks of the trial the tops were cut from the legumes, and the avidity with which the animals ate and the increased gains in weight indicated that the practice of topping tall koa haole may be desirable.

Two steers from each lot were slaughtered at the termination of the experiment. The dressing percentages averaged 59 for both lots, but there was better marbling and more fat on the ninth ribs of molasses-fed steers than of the animals not receiving the supplement (see fig. 7). The two carcasses from the latter lot were graded "top medium" and "low good" while both carcasses of steers receiving the supplement were graded "good." (Henke, Work, Burt)

Swine

Protein Supplements in Swine Rations

A second test was completed comparing the value of three protein supplements: tuna-fish meal, roasted soybeans, and soybean-oil meal. The pigs were younger than those used in the previous test, and rates of gain were lower with more feed consumed per pound of gain. Although gains were greater for the lot fed soybean-oil meal, concentrates fed per pound of gain were less with ground soybeans. However, unless soybean production in the Territory increases, the feeding of this form of protein supplement will not be advantageous.

Analyses of samples of back fat from several pigs in each lot gave iodine and saponification numbers within the range for lard oil, suggesting a relatively soft fat for all three lots. The butcher who purchased the animals corroborated these chemical findings. (Work, Henke)

Algaroba Beans for Fattening Swine

A second study has been completed of the value of the algaroba bean (seed pods of *Prosopis chilensis*) in fattening swine. In the first test, ground kiln-dried beans were fed, while in the more recent test sun-dried algaroba beans picked up from under the trees were chopped and fed to pigs, entirely replacing the 64 percent of barley in a standard ration. The barley-fed pigs reached market weight in 63 days with an average daily gain of 1.44 pounds, while the algaroba-fed lot required 148 days, with an average daily gain of only 0.59

pound. For the former lot 4.99 pounds of the concentrate ration were consumed per pound of gain; for the experimental lot, 11.58 pounds were required. From the standpoint of efficiency of gains and time required to reach market weight, also an economic factor in swine production, chopped sun-dried algaroba beans did not appear to be a desirable feed for swine when completely replacing barley in the ration. (Work, Henke)

Hawaiian Fruits in Swine Rations

Further experimental work was conducted to determine the value of avocados and of papayas in fattening swine. In each case, 1 pound of the fruit was fed with 2 pounds of the standard ration. When avocados were fed, a total of 7.51 pounds of concentrates were consumed per pound of gain, as compared with 5.74 pounds of the standard ration. Concentrates consumed when papayas constituted one-third of the ration were at the rate of 6.38 pounds per pound of gain, with the check lot requiring 4.76 pounds.

The tests indicate that these Hawaiian fruits may have some value for fattening swine, but further work will be necessary to determine to what degree they may be most advantageously incorporated in the rations. (Work, Henke)

Pineapple Bran, a Byproduct of Hawaiian Industry

A further trial was conducted, with 72-pound pigs, in which a part of the barley in the fattening ration was replaced with the local byproduct, pineapple bran. In this experiment, 27 pounds of pineapple bran plus 3 pounds of extra protein supplement were substituted for 30 of the 64 pounds of barley in the standard ration. The average daily gain was only 1.28 pounds on pineapple bran, as against 1.44 pounds for the check lot. However, the feed per pound of gain was 4.76 pounds for the check lot and 4.92 pounds for the pineapple bran lot. At prevailing prices the feed cost per pound of gain was thus reduced from 7.09 cents to 6.79 cents, which might compensate for the additional time required for the pigs to reach market weight. (Work, Henke)

Nonprotein-Nitrogen Studies

Cattle

During the year five Holstein heifers, sired by the same bull, were used in a test of the value of urea as a supplement to a low-

protein ration, as compared with standard protein supplements. One heifer, used as a check, was fed a ration containing, on a moisture-free basis, 8.4 percent protein; two heifers were fed a standard ration containing 20.6 percent protein; and two received a urea ration, the protein equivalent of which was calculated to be 20.7 percent (protein = nitrogen $\times$ 6.25). The daily gain in weight by the heifer on the low-protein ration was 1.01 pounds; the average daily gains on the standard-protein ration and the urea ration, respectively, were 1.42 and 1.14 pounds.

When the check ration was supplemented with urea the nonprotein nitrogen produced approximately one-third of the extra gains made by heifers receiving standard protein supplements. (Work, Henke)

Swine

It is commonly accepted that bacterial synthesis in the rumen is necessary for nonprotein nitrogen to replace ordinary proteins in rations fed to animals. However, a pilot test with two pigs was instituted to determine whether urea could be utilized by nonruminants as a supplement to barley. One animal made a reasonable gain, although not equivalent to the gains of pigs on a standard fattening ration, and one was definitely inferior.

In a second test, lasting 63 days, dried pineapple pulp was substituted for one-half the barley. This ration was so deficient in growth-promoting properties that the pigs were losing weight during the last 12 days of the period. Replacing the pineapple pulp with cassava meal was of no benefit. When half the urea was replaced by tunafish meal, the pigs improved.

Both pigs were slaughtered, and post mortem examination revealed kidney damage in one pig. (Work, Henke)

Chemistry and Soils

Effect of Fertilizers on Yields of Coffee

The fertilizer experiments with coffee trees maintained at the Fukuda, Takashiba, and Akamatsu farms in the Kona District have been concluded. Complete statistical analyses of harvest data for 8 years at the Fukuda farm indicated that, despite great annual fluctuations, significantly higher yields may be expected from trees fertilized with nitrogen and potassium than with either element alone. Phosphorus did not appear to be a limiting factor.

Harvest data from the Takashiba experiment for 3 years also pointed to great annual fluctuations in yield, and to higher yields for trees receiving nitrogen in conjunction with potassium. At this location, trees which received annual dressings of 80 pounds of nitrogen in conjunction with potassium and phosphorus yielded as well as trees receiving 160 pounds of nitrogen plus the two other elements. A summary of yields and statistical analyses of the Fukuda and Takashiba experiments has been published.

A 2×2 factorial experiment was conducted at the Akamatsu farm, designed to determine the effect of adding double dressings of nitrogen and phosphorus. Analysis of the results of this experiment indicated that a double dressing of nitrogen gave a significant increase in yield, but a double dressing of potassium produced no response. The interaction between nitrogen and potassium was negative, although not significantly so.

Analyses of three independent, composite samples of the bark of the trees indicated that the Akamatsu trees were higher in potassium and lower in nitrates and total nitrogen than the Fukuda or Takashiba trees, indicating the possible use of tissue analyses as guides in coffee fertilizer practices. (Dean, Fukunaga)

Mineralizable Nitrogen in Soils

A study of changes in nitrate content of soils, reported last year, showed an initial phase of rapid nitrogen release lasting for about 3 weeks, followed by a slow constant phase for the duration of a 10-month period. After continuation of this latter phase through a

total of 63 weeks, a means of rejuvenating the soils was sought, to reproduce rapid release. A sample of each soil under test was air-dried for 1 week and then wetted to optimum conditions, with the desired effect. The second phase of rapid nitrogen release thus produced was similar in extent and duration to the initial phase.

Further information as to the effect on mineralizable nitrogen of drying soils was obtained by following the changes in three moist field soils brought into the laboratory. Drying the soils caused material increases in the amounts of mineralizable nitrogen, but storage of the soils at different moisture levels for as long as 5 weeks had little or no effect.

At monthy intervals over a period of 8 months, soil samples have been taken from 10 rainfall stations, immediately wetted to optimum conditions, and incubated for 3 weeks, and the mineralizable nitrogen has been determined. The results of these determinations indicated an inverse relationship between the rainfall and the nitrogen contents. The samples from stations where there were no changes in crops showed this relationship much more clearly than where crop changes occurred. (Fukunaga)

The Nature of Organic Phosphorus in Soils

Work by other investigators has led to the assumption that organic phosphorus in soils occurs chiefly in the nucleic-acid form. The claims, however, are based on the identification of the hydrolysis products of impure preparations from soils. A study was conducted to isolate definite organic-phosphorus compounds from soils, prior to interpreting the value of the phosphorus.

The separation of an ash-free, organic-phosphorus-containing fraction has been accomplished by the development of new procedures entailing: (1) Sodium hydroxide-sodium carbonate extraction; (2) separation of organic phosphorus by an isoelectric precipitation; and (3) removal of ash by absorption of organic phosphorus on charcoal. Analyses showed the fraction to contain, typically, 7.4 percent phosphorus and 6.9 percent nitrogen, and to be representative of over 50 percent of the total soil organic phosphorus.

A study of the hydrolysis rate of such compounds indicated that organic phosphorus accumulates in soils in the form of pyrimidine nucleotides and not as nucleic-acid molecules. (Yoshida)

Radioactive Phosphorus in Soils

Two shipments of radioactive phosphorus in the form of sodium phosphate have been received during the past 6 months, through the courtesy of the radiation laboratory of the University of California, for use in a study of the movement of phosphorus applied to soils and its uptake by the plants. With a Lauritsen quartz-fiber electroscope, accuracy within 1 percent was obtained when measuring the radioactive phosphorus in solutions, and within 3 percent for soils and plant ashes. Data obtained on the rate of sorption by soils and the movement of phosphorus through soils concurred with the previous findings of investigators working with nonradioactive phosphorus.

Preliminary pot experiments with tomato plants indicated that the most rapid uptake occurred when the phosphorus was placed approximately 1 inch below and 1½ inches to the side of the crown of the plant. When the phosphorus was dissolved in water, mixed with the soil, and the soil leached, the rate of uptake was more rapid than from a surface application of phosphorus. (Ballard, Dean)

Organic Base Exchange Properties of Hawaiian Soils

In a study of a series of soils representing the Hilo and Hamakua coasts, the proportion of total base exchange resident in the organic matter was determined by calculating the difference between the base exchange capacity of the original soil and of the soil after it had been ignited at 275° C. for 48 hours. The results indicated that from 75 to 95 percent of the base exchange capacity of these soils is organic. Apparently, the soils from areas of high rainfall have the greatest organic base exchange capacities. (Ayres[1])

Electrometric Determination of Base Exchange Capacity

The leaching method of determining the base exchange capacities of soils has proved unsatisfactory in Hawaii, particularly with the high-organic soils common to the Hilo and Hamakua coasts. Consequently, the method of electrometric titration was investigated. The general procedure, by this method, is to add increasing amounts of a standard calcium-hydroxide solution to fixed amounts of soils previously saturated with hydrogen. When equilibrium is obtained, the pH of each suspension is determined and the base exchange

[1] A. S. Ayres, assistant chemist of the Experiment Station of the Hawaiian Sugar Planters' Association, employed by this station from May 1 to June 30, 1939.

capacity calculated from the buffer curve. Tests showed that, with the soils in question, a satisfactory point of equilibrium was difficult to establish; consequently, an extensive study was undertaken of the rates of reaction of hydrogen-saturated soils and calcium hydroxide. Reproducible reaction rates were obtained with soils subjected to a violent shaking with water, prior to the addition of the calcium hydroxide. Thereafter a gentle agitation was sufficient. By plotting the logarithm $(a - x)$ against time, where a is the initial concentration and x the amount reacting in time t, it was found that a uniform rate of reaction took place for the first 4 hours, followed by a slower rate traceable for as long as 2 weeks. The base exchange capacity corresponding to the amount of calcium hydroxide reacting at the end of 4 hours agreed favorably with the results obtained by leaching methods. (Bartlett)

Routine Analyses

During the past year 307 soil samples were analyzed, using the Truog-Hellige soil tester. Of these, 176 were received from farmers either directly or through the Agricultural Extension Service, an almost threefold increase over the number received from farmers the preceding year. The other 131 soil samples analyzed were received from various departments in the experiment station.

Miscellaneous chemical analyses made by the department numbered 23. These consisted chiefly of analyses of irrigation waters and poultry feeds.

Entomology

Ecology of the Tomato Bug, Cyrtopeltis varians

Studies on the attack of *Cyrtopeltis varians* (*Engytatus geniculatus*) on the tomato plant have been made in the greenhouse under cage conditions. Results to date indicate that the attack is mainly on the stems, leaf petioles, and veins, and that oviposition occurs in these same plant parts but in separate oviposition punctures. Feeding scars appear approximately 40 hours after beginning of attack, and a marked increase in scar formation is noted with the appearance of the first nymphs. Bug attack results in the production of a more bushy plant with markedly swollen nodes and short internodes. Plants attacked by bugs produce more flower buds than do check plants, but blossom production is retarded, the number of blossoms is less, the blossoms are reduced in size, and blossom shedding is more marked. The date of first fruiting is later in bug-attacked plants, and the yield is reduced.

The tomato bugs are carnivorous as well as herbivorous, attacking such insects as aphids and mealy bugs or, in the absence of other species, nymphs of their own species. The studies provide no evidence that the bugs transmit a virus, although the incidence of virus disease is usually high in regions in which the bugs are abundant.

General observations in the field suggest a relationship between climatic conditions and prevalence of the bug. Lualualei, where the bug is most abundant, is one of the hottest, driest sections of Oahu; decrease in abundance appears to follow a decrease in temperature and an increase in moisture.

Plants are apparently not attractive to bugs until a few weeks after transplanting when they reach a height of approximately 6 to 8 inches and the first blossom buds have just appeared or are about to appear. The number of adult bugs and nymphs per plant increases as the plants increase in age until about 9 to 12 weeks from the date of transplanting; thereafter the number decreases. The infestation of plants of the same age varies according to the size of the respective plants.

Following is a list of hosts on which *Cyrtopeltis varians* has been found breeding: Tomato, tobacco, eggplant, potato, squash, ornamental geranium, and a species of ornamental plumbago. Tomato is the only one of these hosts on which prolific breeding and high populations have been observed. No predators or parasites have yet been recorded in Hawaii. (Holdaway, Look[1])

Biological Control of Cabbage Worm, Pontia rapae

As the first phase of a project to increase the biological control of the cabbage worm, *Pontia rapae*, in the Territory, a study has been made of parasites already present, their distribution, and the degree of parasitism by each. 1,539 individuals (1,316 larvae and 223 pupae) were examined from 17 collections made on 5 islands. Five species of parasites were obtained: *Apanteles glomeratus, Frontina archippivora, Brachymeria obscurata, Hyposoter exigue*, and *Pteromalus puparum*. None of the three last mentioned is of importance in reducing abundance of the cabbage worm, *B. obscurata* having been found on only five individuals from two localities, *P. puparum* on two individuals from two localities, and *H. exigue* on one individual. *Frontina archippivora* was recorded from all except one collection; parasitism by this insect ranged from 1 to 22 percent, averaging 8 percent. It is primarily a parasite of the army worms, rather than the cabbage worm.

Apanteles glomeratus is the most important parasite collected. As far as is known, it is specific to members of the genus *Pontia*. It is present on all islands and occurs from sea level to elevations of 4,000 feet. The percentage of parasitism ranged up to 74, but was lowest on the farms where insecticides were used. Parasitism by *Frontina archippivora* is not so adversely affected, if at all, by insecticides. (Holdaway, Suehiro)

Possible Vectors of a Virus Disease of Papaya

In view of the increasing importance of papaya fruit for local consumption and for export, and the recent appearance of a disease found to be due to a virus, a study has been made of insects occurring on papaya. To date 49 species from 28 families have been recorded, but few of these can be considered major papaya insects.

[1] Temporary employee from November 1938 through June 1939

However, the patchy occurrence of the disease in time and place suggests that the vector may be a casual or incidental visitor to the papaya.

Transmission experiments from diseased to healthy papaya have been conducted with most of the recorded species considered likely to be virus vectors, as well as with some other species known to be virus vectors in Hawaii although not yet recorded on papaya, with negative results:

Nysius coenosulus, which normally feeds on portulacas and amaranths but which has been found feeding on young papaya trees;

Thrips tabaci, which is the vector of "yellow spot" of pineapples and "spotted wilt" of tomatoes, and has been obtained on papaya;

Aphis gossypii, *Macrosiphum gei*, *Myzus persicae*, and *Aphis medicaginis*, each a vector of several virus diseases and each found on papaya;

Aphis maidis, the vector of sugarcane mosaic, some of the symptoms of which resemble those of the papaya disease; and

Empoasca solana, a species found on papaya and belonging to the family Jassidae, in which are found several virus vectors.

Heavy infestations of *Myzus persicae* produced symptoms similar to those characteristic of the disease. (Holdaway, Look)

Miscellaneous Entomological Problems

Insects which have recently come into prominence through damage to crops are discussed briefly below:

Lema nigrovittata (striped Datura beetle). This Chrysomelid beetle feeds commonly, in both larval and adult stages, on the foliage of Datura. During the past year it was recorded attacking the foliage of eggplant at Koko Head and Lualualei on the island of Oahu, and at Honaunau on Hawaii.

Listroderes obliquus (vegetable weevil). This serious vegetable insect was first recorded in Hawaii in 1926. In 1929 it attacked lettuce at Hilo, Hawaii. In 1934 it was recorded from the island of Maui. During the past year it was damaging the foliage of potatoes on Maui and, on the island of Hawaii, did serious damage to Chinese cabbage and carrots and also attacked turnips, daikon, and gobo.

This is the first occasion on which it has been observed in numbers sufficiently high to do serious damage. The regions where the insect has caused most serious losses have a cool, moist climate and an elevation of approximately 2,700 feet.

Maruca testulalis (*bean pod-borer*). This insect has caused serious damage to both lima beans and climbing green snap beans at Mokapu, Waialua, and Waipahu, Oahu, all of which locations have dry, hot climates. Observations suggest that much of the damage attributed to the bean butterfly (*Lycaena boetica*) is due to *Maruca testulalis*.

Murgantia histrionica (*Harlequin cabbage bug*). This important insect of mainland United States was first recorded in Hawaii from the Honolulu wharves in 1917. In 1923 it was found breeding on a wild native plant *Capparis sandwichiana* on Ewa coral plains. During the past year it was obtained in numbers on cabbage, kale, broccoli, and Chinese cabbage at Waianae and Lualualei, Oahu. These are the first records of this insect on economic plants in Hawaii. They indicate that the insect has extended its range on the island of Oahu but is still restricted to the hot, dry sections between Ewa and Waianae. The distribution of this insect in temperate regions of mainland United States suggests that, if it is permitted to extend beyond the barriers of the ecological island to which it is at present apparently restricted, it will spread to the more important cabbage areas of the Territory and become a serious cabbage pest in Hawaii.

Solenopsis geminata (*fire ant*). Damage has been caused by this ant to the stems, at ground level, of recently transplanted tomato plants at Lualualei, to young eggplants at Koko Head, and to the underground stems and roots of cucumber seedlings at Waipahu. The replanting of cucumbers necessitated by attack of *Solenopsis* has hampered experimental work on melonfly being conducted by the Bureau of Entomology. The three regions where damage from *Solenopsis* has been observed are dry and hot.

Observations of significance in connection with certain other insect pests are summarized in table 6. (Holdaway, Suehiro, Look)

TABLE 6.—Miscellaneous insect pests of crops in Hawaii

Insect pest	Host plants	Remarks
Adoretus sinicus (Chinese rose beetle)	Snapbean	Some evidence has been obtained indicating varietal differences in susceptibility of snapbeans to attack.
Anthonomus eugenii (Pepper weevil)	Pepper	Has also been recorded on eggplant, potato, and *Solanum nigrum*.
Aphis gossypii (Cotton or melon aphid)	Cucurbits, potato, tomato, eggplant, and papaya	Two peaks of abundance of the aphid on hibiscus have been noted in Honolulu during the year. Evidence of the presence of the Braconid parasite, *Lysiphlebus testaceipes* was found only in January and February.
Aphis maidis (Corn aphid)	Corn	A number of insects attack this aphid but are apparently unable to keep it in check. On two occasions we have recorded it breeding on tomato.
Aphis medicaginis	Snapbean, papaya	Has been recorded on snapbean, papaya, and *Crotalaria* sp.
Bedellia orchilella (Sweetpotato leaf miner)	Sweetpotato	Caused considerable damage to the foliage of sweetpotato at Kawaihae, Hawaii and Poamoho, Oahu.
Dacus cucurbitae (Melonfly)	Cucurbits, tomato, and snapbean	Differential susceptibility of bean varieties has been noted, Kentucky Wonder being less susceptible than McCaslan, and both of them less than Lualualei.
Empoasca solana (Potato leafhopper)	Potato, snapbean, lima bean, and papaya	Particularly abundant on Oahu in dry, hot regions; the routine spraying with Bordeaux, arsenate of lead, and nicotine sulphate appears to keep attack on potatoes low.
Epitrix parvula (Flea beetle)	Eggplant, potato, tomato	In some sections this insect is an important pest of eggplant.
Gnorimoschema lycopersicella (Tomato pinworm)	Tomato	Reported to be abundant on Molokai

TABLE 6.—Miscellaneous insect pests of crops in Hawaii (continued)

Insect pest	Host plants	Remarks
Gnorimoschema operculella (Potato tuber moth)	Potato	Routine spraying with Bordeaux, arsenate of lead, and nicotine sulphate at 10-day intervals appears effective against foliage-attacking individuals. *Apanteles scutelaris*, an introduced parasite has not yet reduced the population adequately; exposed tubers are attacked and the foliage of volunteer plants growing during the warmer months is also attacked.
Heliothis armigera (Corn earworm)	Corn, tomato	Apparently breeds on corn throughout the year at most elevations at which corn is grown. Reported to have caused heavy losses to tomatoes at low elevations on Molokai. Occurred on potato foliage in potato fields of Oahu and Molokai.
Hellula undalis (Cabbage webworm)	Head cabbage, kale, broccoli Chinese cabbage, mustard green, and most other cruciferous truck crops	Damage has been observed in the dry, hot sections of Oahu.
Macrosiphum gei (solanifolii) (Green potato aphid)	Potato, tomato	Has been recorded on papaya.
Myzus persicae (Peach aphid)	Tomato, potato, papaya	Of four species of aphid recorded on papaya, this species breeds most readily. High populations developed on young papayas are capable of considerable damage and may necessitate spraying.
Pantomorus godmani (Fuller's rose beetle)	Cabbage, pepper, broccoli, and Chinese cabbage	Recorded on the island of Hawaii.
Peregrinus maidis (Corn leafhopper)	Corn	Particularly abundant at low elevations: a predaceous bug, *Cyrtorhinus lividipennis*, has been introduced by the Board of Agriculture and Forestry.

TABLE 6.—Miscellaneous insect pests of crops in Hawaii (continued)

Insect pest	Host plants	Remarks
Plusia chalcites (Green garden looper)	Potato, snapbean, eggplant, papaya	This looper occurs on many vegetables. It is commonly parasitized by *Litomastix floridana*. It was abundant on potatoes on Oahu during the past winter.
Pycnoderes quadrimaculatus (Bean capsid)	Bean, pumpkin	Abundant in dry, hot sections of Lualualei, Oahu and Kona, Hawaii.
Thrips tabaci (Onion thrips)	Onion, tomato	This vector of "spotted wilt" of tomatoes has been found breeding on green beans, potato and papaya. It is capable of producing malformed leaves of young papaya trees.
Saissetia nigra (Black scale)	Eggplant	May be abundant on eggplants grown for a second crop.

Cutworms—Undetermined species of cutworms caused considerable damage to truck crops, particularly cabbage, in the Volcano and Waimea regions on the Island of Hawaii, elevation 3,000 to 4,000 feet. At upper Ulupalakua, Maui, elevation 4,000 feet, *Agrotis ypsilon* was active.

Mites—Mites have occurred in abundance on strawberries and various ornamental plants, in addition to the crops listed last year. A blood-sucking mite, *Lyponyssus bursa* (tropical fowl mite) has attacked persons occupying private homes on Oahu and Maui. The source of infestation has been traced to sparrows or mynah birds nesting in the eaves or attics of the house. Removing the birds and destroying the mites in the dwelling with a pyrethrum insect spray brings control.

Horticulture

Truck Crops

Snap Beans

Since the widespread appearance of the bean rust fungus (*Uromyces phascoli typica*) in the Territory, the locally popular pole green-podded variety Lualualei cannot be grown in many areas. Investigations are being carried on to isolate rust-resistant varieties which are commercially available and, from among the unnamed introductions, those with pod types approaching the variety Lualualei; and to develop rust-resistant strains of Lualualei.

As reported last year, four commercial rust-resistant varieties have been introduced. Figure 8 shows the pod types of these four varieties, as compared with that of Lualualei. Field tests during the

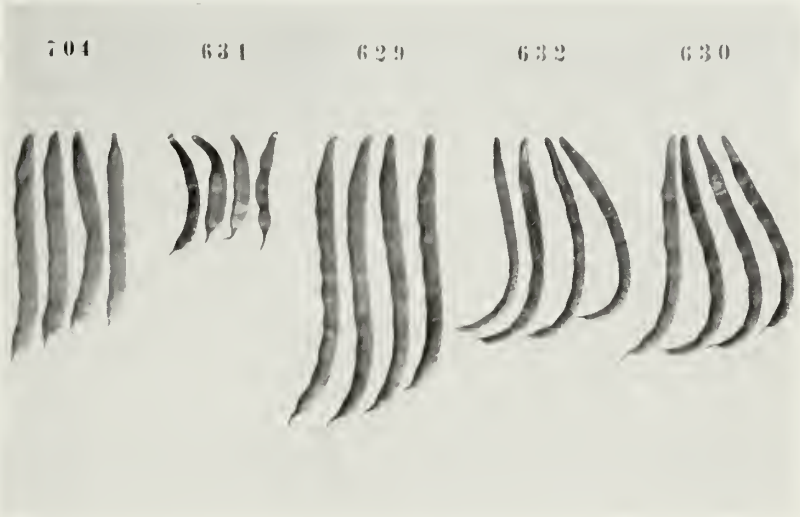

FIGURE 8.—The local pole green-podded snap bean, variety Lualualei, and four commercial rust-resistant varieties: 704, Lualualei; 631, Lazy Wife; 629, Rust Resistant Morse's 191; 632, Kentucky Wonder Brown Seeded Rust Resistant; and 630, Kentucky Wonder Rust Resistant Brown Seeded. (631 and 632 from Associated Seed Growers; 629 and 630 from Ferry Morse Seed Co.)

year indicated that, under disease conditions, the two Kentucky Wonder strains and Rust Resistant Morse's 191 produce higher yields than Lazy Wife or Lualualei. Even under conditions of mild infection the three varieties yield as well or better than Lualualei. Rust Resistant Morse's 191 appears to be the least resistant of these introductions. Lualualei continues to demand the highest prices in the market, but the differential is small and the grower is much less sure of his crop. In addition to the four commercial introductions, Kabuto, a curved, broad, flat-podded variety grown on Maui, has proved to be resistant.

The isolation of rust-resistant unnamed introductions has become more difficult since accessions previously resistant or immune are now more susceptible to the fungus, probably due to a strain of the organism not present in previous studies. Investigations will continue, however, with the varieties possessing desirable pod types or evidencing particular vigor and producing high yields.

There still exists a need for the development of rust-resistant strains of Lualualei, and a hybridization program is being conducted. The supplementary lines of approach were initiated because of the time involved in developing new strains, and in order to determine the qualities of parental material to be used in breeding. (Welch, Parris)

Varietal Testing

Experiments to determine commercial varieties of truck crops adapted to local conditions have continued. Tests conducted during the year at Waipahu lead to the following conclusions:

Cabbage. Yields of desirable head sizes were in the order of Resistant Detroit, Golden Acre, and Copenhagen Market. The last-mentioned variety is the standard in the Territory.

Cauliflower. The standard high-elevation variety, Snowball, was considerably surpassed in percentage of No. 1 heads and earliness during the winter months by the varieties Early Patna, Early Market, and Early Benares, introduced from India.

Celery. Excellent yields of good quality of the varieties Golden Detroit, Florida Golden, and Golden Pascal were obtained during the cool season.

Eggplant. Of the round-fruited types, Black Beauty appeared to yield significantly more No. 1 fruits and combined No. 1 and No. 2

fruits than Florida High Bush and numerically more than New York Improved Spineless. Black Beauty significantly outyielded all long-fruited types tested.

Lettuce. In the cool season certain strains of Cosberg compared in firmness with the Imperial strains grown in California and produced twice as many firm heads as Mignonette. In the warm season, however, Mignonette and hybrid selections of this variety exceeded the Cosberg strains. The performance of Imperial No. 44 was superior at Waipahu to that of the standard high-elevation variety, Imperial No. 152.

Peas. Standard mainland varieties of garden peas are not suited to environmental conditions at Waipahu and, in addition, are seriously affected by root rot. Certain varieties from Australia and the Creole variety from Louisiana showed resistance to this disease. (Welch, Sumida)

Potatoes

Breeding and Selection

Plantings are being made at Poamoho farm in an effort to select potato varieties which exhibit good quality with high yield. The new Sebago variety and a number of unnamed introductions from mainland breeders offer promise. Certain introductions appear to be resistant to early or alternaria blight, which is a serious fungus disease at low elevations. The virus diseases—spindle tuber, spotted wilt, and mosaic—make difficult the maintenance of healthy seed stocks in the Territory. (Welch, Sumida)

Cultural Methods

Experiments conducted at Poamoho Farm to determine desirable cultural practices included planting in twin, single, and twin-and-single-alternating rows, spacing of the plants at various intervals, and fertilization with organic and inorganic nitrogen. The variety under test was Bliss Triumph.

When potatoes were planted in twin, single, and twin-and-single-alternating rows, no significant differences occurred in yield per acre. Thus single-row planting would appear more desirable since less planting material and fertilizers are required, and because of ease of planting and cultivation.

The test of planting distances included spacing from 6 up to 14 inches with increments of 2 inches, in rows 3 feet apart. No significant differences in yield per acre occurred within the range from 6 to 12 inches, indicating that a 12-inch planting distance within the row gave maximum yield with a minimum of seed.

In a comparison of the value of organic with inorganic nitrogen in the standard 12-30-6 potato fertilizer, neither treatment was superior in yield of No. 1, No. 2, or No. 1 plus No. 2 potatoes. On the basis of No. 1, No. 2, and cull tubers combined, the inorganic outyielded the organic nitrogen plots. (Welch, Sumida)

Breaking of Dormancy

Treatments of seed potatoes to accelerate germination included dips of 3 percent thiourea, 2 percent sodium thiocyanate, 6 percent ethylene chlorohydrin, and vaporized ethylene chlorohydrin at 1 cc. for each kilogram of potatoes. To date the most effective treatment appears to be ethylene chlorohydrin, applied in either manner. Since rapid evaporation necessitates that the seed dipped in this solution be sealed in air-tight jars for several day after treatment, vaporization is probably the simpler method. A treatment period of 2 to 3 days seems most desirable, and the potatoes should be stored for 2 weeks prior to planting. (Michener)

Papaya

Sterilization Treatments

Quarantine laws were modified, effective November 1, 1938, to allow the entry of Island fruits and vegetables to the mainland, with either of two prescribed treatments: (1) Cooling the fruit or vegetable until its approximate center reaches 35° F. and holding this temperature for a period of 15 days; or (2) heating the fruit or vegetable until the approximate center reaches 110° F. and holding this temperature for a period of 8 hours. Later a clause was added requiring that the relative humidity be maintained at 100 percent during the 8-hour period of the heat treatment. Major interest in the application of sterilization treatment has been in connection with the papaya, but in order to understand the effects of the prescribed methods it was necessary to determine first the normal ripening process of the papaya. (Jones)

Normal Ripening Process

From the time of beginning of ripening in the fruit until full ripeness is attained, the process is continuous. The first noticeable change is the development of yellow color in the funiculus. The color then spreads outward, and full ripeness is attained when the outer surface is completely yellow. At the same time the physical characteristics of the flesh, from tough and rubbery, become very soft and crushable. Associated with these developments are changes in the chemical composition and respirational activity of the fruit.

The outstanding change in chemical composition is in the relationship between sucrose and reducing sugars. In the green fruit, 42 percent of the total sugars occur as sucrose, while in the ripe fruit only 18 percent of the total sugars occur as sucrose. The acid-hydrolyzable material drops from 9.33 percent of the total dry weight in the green fruit to 4.36 percent in the ripe fruit. As no starch is

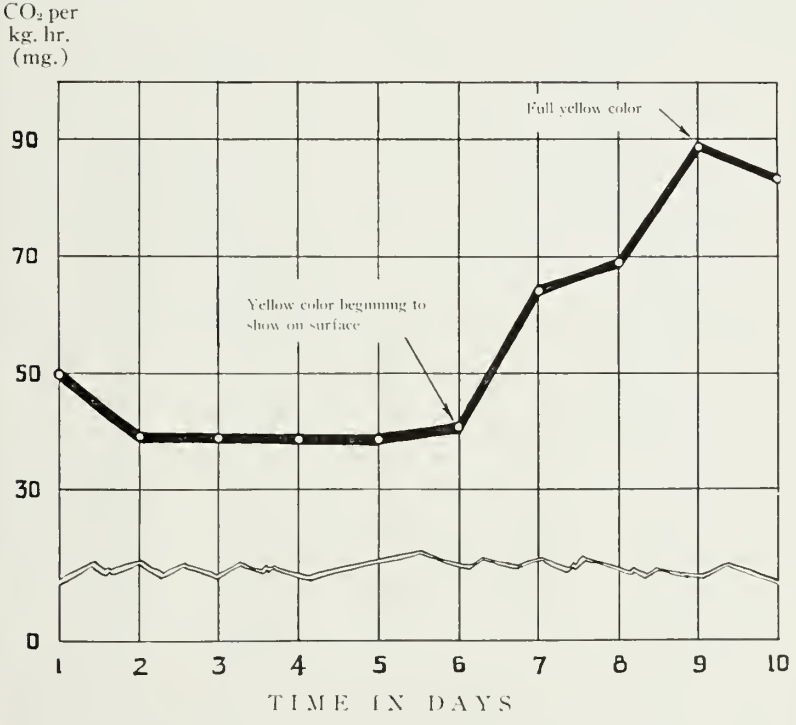

FIGURE 9.—Respiration of papaya fruit during ripening at approximately 77° F

present in the papaya, this decrease represents a change in cell-wall constituents and accounts, at least in part, for the change in consistency of the flesh during ripening. There is apparently no significant alteration in the nitrogen content during ripening.

As the color in the fruit develops, the rate of respiration, as measured by carbon-dioxide elimination, rapidly increases and reaches a peak simultaneously with the full color development (see fig. 9). After this peak, the rate of respiration falls. In some instances it rises again, but this can be attributed to the growth of fungi on the overripe fruit and to the leakage of internal gases through the wounds caused by the fungi. Before the development of external color and

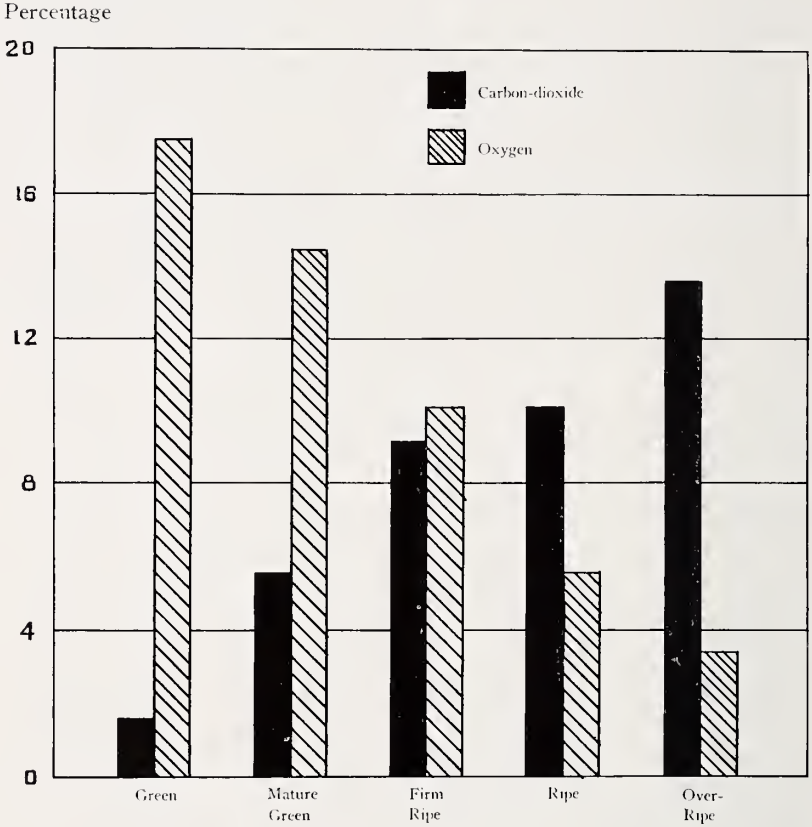

FIGURE 10.—Carbon-dioxide and oxygen contents of the internal cavity of the papaya at progressive stages of maturity

before the rate of external elimination of carbon dioxide begins to increase, the concentration of carbon dioxide in the internal atmosphere has begun. This increase in carbon dioxide in the internal atmosphere (see fig. 10) continues throughout the ripening period and past full ripeness. Thus, there is no peak of internal carbon-dioxide concentration. As the carbon-dioxide content of the internal cavity increases, the oxygen content decreases. (Jones)

Effects of Treatment at 35° F.

After 15 days' storage at 35° F., the papaya, removed to room temperature, develops small surface pits within 1 or 2 days. These pits serve as places of entrance for fungi; within 3 or 4 days the fruit is overrun with fungi, and breakdown proceeds without ripening.

Cold storage prevents the hydrolysis of sucrose and cell-wall constituents, slows the process of respiration, and prevents the climacteric rise in respiration. These processes are not resumed on removal from cold storage. (Jones)

Effects of Treatment at 110° F.

This treatment has proved more satisfactory for the elimination of fruitfly. The fruit may or may not be injured by the treatment depending upon the treating medium and the physiological condition of the fruit. Uninjured fruits are equal to or better than untreated fruit in flavor, aroma, color, and texture. Injured fruits have an unpleasant and disagreeable odor and a cooked flavor; the injured portions of the flesh, usually the innermost tissues, and the funiculi change from golden orange to bright lemon yellow in color. Several days after treatment, injury in some cases is expressed as a blackening of the vascular bundles. In ripe fruit the injured areas become soft and translucent; in less ripe fruit the injured portion of the flesh becomes a hard case surrounding the seed cavity as the uninjured portions continue normal ripening.

In studies on the influence of the treating medium on fruit tolerance, it was found that: (1) The use of air fully saturated with water throughout the entire high-temperature treatment of Solo papayas resulted in maximum injury. (2) Minimum injury resulted from a conditioning period of 6 hours with air at 100° F. and 60-percent relative humidity, followed by a period of approxi-

mately 2½ hours with air at 60-percent relative humidity and 110° F., before the required 8 hours with the fruit temperature at 110° F. and the air at 100-percent relative humidity. (3) In general, ripe fruits were less resistant to injury than firm-ripe or mature-green fruits during the high-temperature treatment.

In addition to papayas, several island-grown vegetables have been given the vapor-heat treatment. These are: Chinese peas, Lualualei green beans, yellow wax beans, cucumbers, lima beans, tomatoes, bell peppers, eggplants, and avocados. (Jones)

Ethylene from Papayas

An inspection of figure 9 shows that, from the beginning of coloration of the fruit, there is a marked and rapid increase in the production of carbon dioxide. Apparently something occurs in the physiology of the fruit to cause this metabolic activity and it was thought that, as in other fruit, ethylene was being produced. Since ethylene is known to cause a green banana to ripen rapidly, several green bananas were sealed in a jar (1) with a ripening papaya, (2) with a green papaya, and (3) alone. After a period of 48 hours the following results were obtained:

1. Papaya ripe—bananas yellow and fully ripe.
2. Papaya green—bananas green; no ripening.
3. Bananas alone—bananas green; no ripening.

These results indicate that during ripening the papaya fruit produces some gas that brings about a rapid ripening of bananas. Other work is planned on this problem. (Jones)

Genetics

A series of crosses has been made, to determine occurrence of pistilloidy in hermaphrodite fruits of the papaya. Three types of hermaphrodites have been recognized and designated as Types II, III, and IV. Type IV is commercially desirable; Type III, which is irregular in shape, appears when some of the inner whorl of five stamens become carpels and unite, often imperfectly, with the pistil; and Type II is often more regular in shape but is apparently a more complete case of pistilloidy in which all of the inner whorl of stamens and some of the outer have become pistilloid. Although one or another of these types often predominates, the total proportion of pistilloid fruits may fall anywhere between 0 and 100 percent.

FIGURE 11.—Types of hermaphrodite fruit: The lower left-hand fruit is Type IV; the two fruits above it are Type III; and all the others are Type II

A number of progenies from controlled pollinations were examined, and estimates were made of the proportion of pistilloid fruits on each tree. Data on a number of these trees are presented in table 7.

TABLE 7.—Frequency of pistilloid fruits in progenies of controlled papaya pollinations

Parents	Number of trees examined	Hermaphrodite trees having pistilloid fruits in the proportion of—					
		No pistilloid fruits	0 to 10 percent	10 to 25 percent	25 to 50 percent	50 to 90 percent	90 to 100 percent
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Hermaphrodite (type IV fruits) × male	84	65.4	29.8	3.6	1.2		
Hermaphrodite (type IV fruits) selfed	143	13.2	69.3	14.7	2.1	0.7	
Female × hermaphrodite (pistilloid fruits)	114	39.5	24.5	18.4	9.7	7.9	
Hermaphrodite (pistilloid fruits) × hermaphrodite (type IV fruits)	148	17.5	43.8	20.5	13.5	4.7	
Hermaphrodite (pistilloid fruits) × hermaphrodite (type IV fruits)	156		5.8	25.0	27.0	36.4	5.8

The limits of the classes used in segregating these trees are, of course, purely arbitrary; but when intervals of 5 and 10 percent pistilloidy were used, it was still impossible to detect any simple Mendelian segregation. Pistilloidy appears to be determined by a series of multiple factors, and it follows that selection of trees which produce few or no pistilloid fruits should eliminate or minimize the occurrence of undesirable types. Unfortunately, hermaphrodite trees, and especially those trees having no pistilloid fruits, have the characteristic of forming sterile flowers, with a resulting lack of fruit production, during the late summer and fall. It is possible that

selection of breeding trees with a small proportion of pistilloid fruits may increase production by reducing the number of trees tending to produce sterile flowers. (Michener)

Colchicine Experiments

During the past year the drug colchicine has been employed in connection with a cytological study of chromosome morphology of *Carica papaya*. Several methods have been used in treating the Solo variety and Accession No. 382, of which application of an aqueous solution of the chemical to the growing points of young seedlings has been the most effective. An 0.4-percent solution applied at hourly intervals for 4, 8, and 12 hours produced characteristic slowing of growth, twisted, thickened, and misshapen leaves, and callus tissue. Some plants were tetraploid in appearance following treatment, but after being planted in the field they gradually reverted to the normal diploid type. This was especially true of the Solo variety, which did not respond to the treatment as well as did the accession. A year after treatment some plants of the latter variety are only 2½ feet tall and just beginning to flower whereas the controls and Solos are 6 to 9 feet in height and bearing fruits.

Examination of the pollen from treated plants failed to reveal the presence of any giant-size grains. Stomata size and number were determined by means of collodion films, and only one accession plant showed differences from the control. This is one of the dwarfed plants only now beginning to flower (see fig 12).

Although the results to date have not been striking, they are encouraging, and the project is being continued and broadened to include other tropical plants. (Hartung)

Breeding and Selection

The Solo, in spite of its variability, is by far the best variety of papaya now grown in the islands; consequently a number of selections are being made on the bases of abundance of fruit, desirable size and shape, and uniform thickness of flesh. The selected trees have been self-pollinated, and the seeds are now being harvested and planted.

With regard to fruit size, it is desirable to establish lines having small fruits and others having larger fruits, as small fruits are preferred for shipment to the mainland and large for the local market.

FIGURE 12.—Effects of colchicine treatments on papaya seedlings: The stunted tree in the right foreground was planted at the same time as the other trees in the picture; temporary effects of colchicine on all the trees is evidenced by callus tissue at the bases

Other work indicates that the tendency of trees to produce unmarketable fruit of irregular shape can be largely eliminated by selection. Most desirable is the pear shape of the elongate Solo papaya, with smooth skin and without deep longitudinal furrows. It is also desirable to avoid fruits with irregularities on the inside surface of the flesh for this characteristic makes removal of the seeds difficult.

It is probable that selection of the better types of Solo will lead to further improvement. However, the possibility remains of finding other superior varieties, and many accessions have been introduced from other parts of the world, with the hope that they may either be of good quality for growing here or that they will have certain desirable characteristics which will make them useful as breeding material.

A large number of papaya varieties have been grown, and so far none has been as good as the Solo. An introduction from Haiti has two desirable characteristics: greater resistance to mildew and other leaf diseases, and earlier fruiting than Solo. Unfortunately the fruit is not good, but by crossing with Solo it may be possible to combine the desirable qualities of both varieties. Such a cross has been made but it will be necessary to wait for the growth of the F_2 generation and backcross. (Michener)

Small Fruits

Berry Culture

Fifty plants each of the boysenberry and youngberry were set out at the Haleakala Branch Station for observation and preliminary pruning and training treatments. The plants have made fair growth but will not fruit until 1940. Eighteen varieties of the newest types of everbearing and June-bearing strawberries developed in recent years for southern conditions on the mainland were set out at Haleakala and at the Kona station. There is a possibility that one or more of these varieties may be adapted to Hawaiian conditions, particularly at relatively high elevations. Several years will be required to complete the test. (Beaumont)

Asexual Propagation of the Litchi

To induce rooting of litchi cuttings, a number of substances known to favor root formation have been applied. Indole acetic acid has

produced the most favorable results, but in order to achieve a maximum percentage of rooting, it is desirable to plant the cuttings in a propagating bed with the rooting medium held at a temperature of from 86° to 90° F. This combination of treatments has induced rooting in as many as 70 percent of the cuttings. Vitamin B_1 is apparently not required by the cuttings for root growth, as plants which were treated with a preparation of the vitamin in addition to the auxin were not superior in root formation to plants treated with indole acetic acid alone.

Although the cuttings form roots, it is still necessary to determine a satisfactory means of growing the young cuttings until they are established as young trees. The cuttings form long, extremely brittle roots and are therefore difficult to transplant. This problem is now receiving attention.

Indole acetic acid, applied in a lanolin paste at the rate of 2 percent, was effective in accelerating root formation in air layering of the litchi. The paste was smeared on the branch at the point where the air layer was to be made, and the branch girdled immediately below this point. (Michener, Minn)

Macadamia

Oil Storage

In a study of the macadamia embryo during development, an almost straight-line increase in the actual amount of oil per embryo was noted from 90 days, when formation of oil begins, until the fruit is mature. The insoluble nitrogen increases as the amount of oil increases. This is contrary to statements in the literature to the effect that in oil-bearing seed the oil content and insoluble-nitrogen content are inversely related.

A full account of this work has been prepared and will appear as a journal article. (Jones, Cooil)

Variety Tests

Three additional tests involving a total of 52 numbered varieties of macadamia were set out during the year. The tests, located at Makawao, Maui; Aiea and Waipahu, Oahu; and Wailua, Kauai, are comparable to those set out in 1937-38, the same three check varieties being used.

Fifty-nine selected varieties now appear in tests on the various islands. Twenty of these occur in replicated tests on Hawaii, Maui, Oahu, and Kauai, so that it will be possible to study growth variations due to place effects. Ten additional varieties have been propagated and will be set out during 1939-40.

During the past three seasons, 2-pound samples of nuts from 46 selected trees have been weighed and measured to determine whether seasonal and other growing conditions affect the characteristics of the nuts produced. Three locations are represented. The average weight of the dried nut was slightly though significantly greater for the 1937 samples than the 1936 or 1938 samples from the same trees at Hoaeae and Nutridge but not at Keauhou. The average weight of dried kernels was remarkably constant in all 3 years at the three locations. The greatest difference between any 2 years occurred at Nutridge, where the kernels were 0.34 gram heavier in 1938 than in the preceding years. No important differences in thickness of shell at the side and base were observed. These results indicate that the varietal characteristics of the nut and particularly the weight of the kernel are quite constant from season to season. (Beaumont)

Cultural Investigations

Experiments designed to compare the rootstock quality of *Macadamia ternifolia* with that of *M. ternifolia* var. *integrifolia* were set out at Waipahu and Aiea, Oahu. Three replications each of eighteen selected smooth-shell varieties, grafted on both rough-shell and smooth-shell rootstocks are included in the two trials. In the Waipahu planting, the varieties are systematically grouped in such a manner that alternate rows of rough-shell and smooth-shell rootstocks occur. (Beaumont)

Chlorosis

The results of a foliar diagnosis of chlorotic and nonchlorotic trees may be summarized as follows:

1. Green leaves contain from 2 to 15 times more manganese, calculated as percentage of total fresh weight, than chlorotic leaves but only slightly more iron and calcium. Chlorotic leaves, on the other hand, contain more potassium, magnesium, and phosphorus.

2. Green leaves contain slightly more insoluble and soluble solids, reducing sugars, and acid-hydrolyzable materials, and from 3 to 14 times more nonreducing sugar than chlorotic leaves, calculated as percentage of total fresh weight. However, chlorotic leaves contain somewhat more insoluble and soluble nitrogen and from two to three times more ammonia and amino nitrogen.

Seventy-two soil samples from five areas were analyzed, but no consistent correlation was found between the pH, phosphorus, potassium, calcium, or magnesium of the soils and the occurrence of chlorosis. It is planned to obtain additional samples for more complete analyses during 1939-40.

Seeds from 32 selected trees were planted in a chlorotic area during 1937-38 to determine whether the progeny from individual trees exhibit differential susceptibility to chlorosis. The results of this test show that significant differences do occur. The experiment is being repeated with seeds from the same 32 and from 17 additional trees.

Seeds from chlorotic trees and from green trees were planted separately in coral sand and were allowed to grow without the addition of any nutrient. The former produce significantly more chlorotic seedlings than the latter. This test will also be repeated, using larger numbers of seeds from more trees. (Guest)

Coffee

An analysis of growth relationships and yield of coffee trees in the Fukuda fertilizer experiment was reported last year. The partial regression coefficients, together with their sampling errors, showed that, when other independent variates were held at their means, (1) the 1937 yield was not significantly affected by the 1936 yield; (2) there was a highly significant and negative relationship between 1937 yield and the terminal and lateral growths, respectively, made in the same year; and (3) size of tree, as indicated by circumference squared, was related to yield. Lateral growth measurements for 2 successive years were not available at the time, and because this measurement bore such a strong negative relationship to yield in the same year, additional records were secured to determine the relationship of this growth to the yield in the following year.

Partial regression coefficients were calculated according to the equation

$$(y - \bar{y}) = b_{y_1}(y_1 - \bar{y_1}) + b_l(l - \bar{l}) + b_{l_1}(l_1 - \bar{l_1})$$

where y = 1938 individual-tree yield of cherry coffee in pounds, y_1 = 1937 individual-tree yield of cherry coffee in pounds, l = 1937 average lateral growth per tree in centimeters, and l_1 = 1938 average lateral growth per tree in centimeters.

The coefficients with their sampling errors and "t" values are as follows:

$$b_{y_1} = -0.196 \pm 0.070;\ t = 2.794$$
$$b_l = +1.005 \pm 0.218;\ t = 4.618$$
$$b_{l_1} = -0.288 \pm 0.189;\ t = 1.530$$

The partial regression of 1938 yield on 1937 yield was highly significant, confirming the relationship found and reported for the yields in 1936 and 1937. The regression of 1938 yield on lateral growth of the previous (1937) season was positive and highly significant in relation to the sampling error, showing that the yield per tree is clearly a measurable response to the lateral growth made in the preceding season and confirming the hypothesis as stated above. In the earlier analysis, the yield bore a significant negative relationship to the growth made in the same year. The 1938 yield and growth data are not convincing. The 1938 yields were low on the average while seasonal and growth responses were good, so that yield apparently did not play a dominant part in affecting growth.

The lateral growth is apparently a relatively accurate means of determining tree response and of predicting yield under normal weather conditions and will be a useful tool in fertilizer, pruning, or other investigations. It will, however, be necessary to develop an expression for volume of tree to be used with lateral growth to predict yield more accurately. (Beaumont)

Plant Introductions

Table 8 is a list of the seed and plant introductions made during the year.

TABLE 8.—Seed and plant introductions made during the year ending June 30, 1939

Scientific name	No. of varieties	Source	Type of material
Anona sp.	1	Brazil	Seed
Acanthoxyris falcata	1	Palmira, Colombia	do
Aristolochia sp.	1	Paraguay (through J. L. Collins)	do
Allamanda schottii	1	do	do
Bomarea sp.	1	Palmira, Colombia	do
Carica papaya	2	Kenya, South Africa	do
Do	3	Coimbatore, India	do
Do	1	Honolulu	do
Do	1	Paraguay (through Collins	do
Do	11	South Africa	do
Do	3	Dr. Traub, Florida	do
Do	1	Calcutta, India	do
Dimocarpus longan	1	P. I. 82409	Plants
Fragaria sp.	18	Maryland	do
Garcinia mangostana	1	Canal Zone	Seed
Jacaratia hassleriana, Chodat	1	Brazil	do
Macadamia ternifolia	3	Queensland, Australia	do
Mangifera indica	4	Java, Dutch East Indies	Scions
Passiflora sp.	1	Argentina	Seed
Do	3	Brazil	do
Petunia violaceae	1	Paraguay	do
Peltaphorum dubium	1	do	do
Rubus biflorus	1	Oregon	do
Tecoma ipe, Mart.	1	Paraguay	do
Wild begonia	1	Brazil	do

Nutrition

Chemical Analyses of Hawaiian-grown Vegetables

Since data on the composition of Hawaiian-grown vegetables have been insufficient or lacking, common vegetables used by all racial groups and certain ones characteristic of specific racial groups are being analyzed. During the year, analyses have been made of 3 Filipino vegetables—camongay pods, saluyot, and catuday—and 12 common vegetables, as follows: 3 varieties of tomatoes; 2 varieties each of lettuce, potatoes (cooked as well as raw), and string beans (one cooked as well as raw); and 1 variety each of wax beans and broccoli (both cooked as well as raw), sweet corn, cucumbers, sweet-potatoes, pumpkins, head cabbage, and asparagus. (Miller, Louis).

Vitamin Determinations by the Biological Method

More than 500 rats have been used to establish curves of response for biological determinations of vitamins A, B_1, and D. The data for vitamin B_1 were analyzed statistically and the results published. It was concluded that, for vitamin B_1 assays, a 3-week feeding period gives as significant results as a 5-week feeding period; that a minimum of twelve rats is necessary for a significant biological assay of foods for their thiamin content; and that when supplements providing quantities of thiamin between 1 and 4 micrograms are fed to groups of twelve rats six times a week the responses should be sufficiently accurate to distinguish differences of 1 microgram. (Miller, Takase, Yanazawa)

Values of Family Living

Further observations on the dietary habits of independent farmer-families in Hawaii show an inadequate consumption of the protective foods and a high intake of cereals and meats. During the year, 56 families in 3 districts on Oahu kept records of all foods consumed over a 28-day period—including the kind, source, quantity, and cost of each food. These families were distributed racially as follows: Japanese, 27; Hawaiian or part-Hawaiian, 25; and Chinese, 4. The data indicate the same dietary deficiencies reported last year in a preliminary survey of 12 Japanese families; namely, very low intakes

of calcium and vitamin B_1 and a slightly less serious deficiency in vitamin A. The 56 families are also submitting information on total value of family living, family income, and farm tenancy or ownership.

Examinations by a pediatrician and a dentist of the 224 children in these families gave clinical ratings of nutritional condition as "good" in 56 percent of the cases; the remaining children showed some evidence of inadequate nutrition. (Potgieter)

Anemia and Blood Value Studies[1]

Influence of Iron on Blood-Forming Organs of Anemic Animals

To determine the effects of iron on recovery from nutritional anemia, 20 rats made anemic from time of weaning by a diet exclusively of milk were fed a supplement of 0.5 milligram of iron daily and killed at intervals of from 1 to 35 days after therapy was begun. Blood studies indicated that none of the animals recovered from anemia, although three rats showed slight improvement. (Hamre)

The Capillary Hematocrit Method of Determining Blood-Cell Volume

In previous studies it has been observed that the red blood cells of anemic rats were abnormally small. Methods of determining the volume included the tedious ones by means of microscope ocular micrometers and the Block refractometer method, or the common method of packed red blood cells which requires large quantities of blood and necessitates venipuncture or heart puncture. The use of the capillary hematocrit method was therefore investigated, and conditions under which it could be used with accuracy were ascertained. The results, which are in press, may be summarized as follows:

Determination of cell volume of capillary blood drawn directly into a pipette is satisfactory if centrifuging is carried out immediately. Wetting the pipette with a one-third-saturated sodium-citrate solution or a 1-percent heparin solution as an anticoagulant and blowing out the excess fluid prior to drawing the blood is an aid in securing consistently accurate results.

Only heparin, thoroughly mixed with small, approximate quantities of capillary blood before the pipettes are filled, permits delayed

[1] The studies on blood values by Dr. Hamre, although not carried on as a project of the nutrition division, are reported herein for their research value.

centrifuging of the sample. When dried anticoagulants are used, delayed centrifuging involves too great an error for practical use. (Hamre)

Hemoglobin and Blood-Cell Levels of Preschool Children

As part of a survey of blood values for residents of the Hawaiian Islands, 179 children were examined (90 boys and 89 girls), of various races and ranging in age from 3 to 6 years.

Variations occurring among the children as to race, age, sex, weight, infection with pinworm, or social and economic status of the parents were not reflected in the blood values. In addition, the mean values for the various hematological elements for this group agree closely with those given for children of this age in other geographic localities. (Hamre)

Survey of Blood Values of Young Men and Women

A similar study conducted with 112 women and 137 men between the ages of 16 and 25 indicated no significant differences in blood values within the group for age or race, but sex differences were observed for the following hematological elements: hemoglobin, number of erythrocytes, volume of packed erythrocytes, and mean corpuscular hemoglobin concentrations. In this age group, too, the mean values for the various blood elements agreed closely with those recorded for residents of other parts of the world. (Hamre)

Parasitology

Liver Fluke of Cattle

Previous work has indicated the value of kamala and of Distol, a proprietary drug, in the treatment of cattle for liver fluke (*Fasciola gigantica*). Experiments during the past year have been conducted to obtain more specific information as to size of dosage and period of administration. In addition, preliminary studies have been made with hexachloroethane, but results to date do not justify the drawing of conclusions as to the safety and efficacy of this drug in destruction of the parasites.

Treatment of Fluky Cattle with Distol

A total of 79 animals were treated with Distol, 73 of which were nonlactating and 6 lactating. In the lactating cows, Distol caused a temporary drop in milk production, followed by a gradual return to normal within 10 or 15 days. The milk acquired a slightly salty, bitter taste for a few days after treatment.

Distol was administered in three dosages: 1 capsule (12.6 grams) to 70 pounds of body weight in 2 days; the same rate in 3 days; and 1 capsule to 80 pounds of body weight in 2 days.

To test the value of the first-mentioned dosage, 41 animals ranging in weight from 320 to 980 pounds were treated. It was found that in 87 percent of the cases in which infection was below 50 eggs per gram of feces, this dosage completely eliminated all adult flukes, as indicated by absence of fluke eggs in the feces. For more serious infection, the cure was not so consistent, but the number of fluke eggs recovered was drastically reduced, indicating elimination of many adult flukes.

Seventeen cows were treated with Distol at the rate of 1 capsule to 70 pounds of body weight, administered in 3 days. In 16 of these cows, the egg count was below 40 per gram of feces and the treatment was 100 percent effective. The seventeenth animal, which was in extremely poor condition, had the egg count reduced from 1,255 to 10, and several hundred dead flukes were passed with the feces on the second day of treatment.

FIGURE 13.—Recovery from fascioliasis: Above (a), fluky cow at time of treatment with Distol and (b), four months later; below (a), fluky cow, (b), treated with kamala. The improvement in appearance is very noticeable with either drug.

To determine whether a dosage of 1 capsule to 80 pounds of body weight, administered in 2 days, would be equally satisfactory for light infections, 21 animals with egg counts ranging from 1 to 19 were treated. Whereas only one of a like group was not completely cured at the rate of 1 to 70 pounds, four animals remained positive when the rate was 1 capsule to 80 pounds of body weight. (Alicata)

Treatment of Fluky Cattle with Kamala

In testing the efficacy of kamala as an anthelmintic, a total of 58 animals were treated, with dosages as follow: 1 capsule (10 grams)

to 60 pounds of body weight, in 3 days; 1 to 70 pounds, in 3 days; and 1 to 70 pounds, in 4 days. At the rate of 1 capsule to 60 pounds, with 30 dairy cows ranging from 690 to 1,240 pounds in weight, 1 animal in poor condition prior to treatment died, but the flukes were apparently completely eliminated from the other cows. The drug had a toxic effect at this concentration, as most of the animals developed exhaustive diarrhea and required 1 to 2 weeks for recovery. Post mortem examination of eight cows 23 days after treatment showed absence of flukes from the livers of 7 cows and one live immature fluke about 15 millimeters long in the liver of the eighth.

When 28 young beef cattle ranging in weight from 176 to 770 pounds were treated at the reduced concentration of 1 capsule to 70 pounds of body weight, the treatment was less than 50 percent effective. All of these animals developed mild diarrhea but recovered within a few days. (Alicata)

Poultry Parasites

Relation of Nutrition to Tapeworm Infection

Experimental work conducted during the preceding year indicated the importance of adequate nutrition in reduction of ascarid infection in poultry. A similar test has since been made to determine the relation of nutrition to infection with tapeworm *(Hymenolepis exigua)*. At time of hatching 25 chicks were placed on a basal ration with animal-protein supplements (fish meal and dried skim milk), and 25 chicks on a basal ration with plant-protein supplements (yeast, sesame meal, peanut oil, and soybean meal). At the age of 3 weeks, each bird was fed 100 infective tapeworm larvae (cysticercoids). Three weeks later all birds were killed. The average number of tapeworms found in the small intestine of each bird receiving the plant-protein supplements was 66; for birds receiving animal-protein supplements the corresponding degree of infection was only 14. Additional tests will be made to confirm the results of this investigation. (Alicata)

Life Cycle of the Caecal Fluke, Postharmostomum gallinum

Detailed studies have been made during the year on the life cycle of *P. gallinum*. Eggs of this fluke, containing mature miracidia, are eliminated with the droppings of infected birds and are ingested by the land snail, *Eulota similaris*. The eggs hatch within the snail, and

the miracidia migrate to the liver, where they develop into branched sporocysts which give rise to cercariae. The latter mature about 60 days after infection and crawl out of the snail only to reenter through the external renal duct and locate themselves in the heart chamber (pericardium). In this chamber the cercariae develop in about a month into adolescariae which are infective when the snail is ingested by chickens. The fluke requires about 24 days in the chicken before reaching the egg-laying stage.

Control of this parasite may be effected by eliminating land snails around poultry yards or confining the birds on wire floors above the ground. (Alicata)

Life Cycle of Pinworm, Subulura brumpti

Two common pinworms parasitize the caeca of local poultry, one of which, *Heterakis gallinae*, requires no intermediate host. The life cycle of the other, *Subulura brumpti*, has been studied during the year. Embryonated eggs of the parasite are ingested by an intermediate host, hatch, and the larvae develop to the stage infective to chickens in about 15 days. Intermediate hosts have been found under natural conditions to be earwigs (*Euborellia annulipes*) and beetles (*Dermestes vulpinus*, *Gonocephalum seriatum*, *Ammophorus insularis*, and *Alphitobius diaperinus*). Under experimental conditions, grasshoppers (*Conocephalus saltator*) have also been found to be possible carriers. About 36 days after ingestion of infected arthropods by the chickens, the larvae reach maturity in the caeca of the birds. (Alicata)

Parasites of Horses in Hawaii

During the past few years a collection of parasites has been made from horses raised and killed in Hawaii. A large number of these parasites were submitted to Dr. A. O. Foster of the Gorgas Memorial Laboratory, Panama, for identification. Listed below are the parasites which have been identified up to the present time. (Alicata)

Parasite	Location found
Bots	
Gastrophilus intestinalis	Stomach
Gastrophilus nasalis	Do

Roundworms	
Trichostrongylus axei	Stomach
Habronema muscae	Do
Habronema microstoma	Do
Parascaris equorum	Small intestine
Cyathostomum coronatum	Large intestine
Cylicocercus catinatus	Do
Cylicocercus goldi	Do
Cylicocercus pateratus	Do
Cylicocyclus leptostomus	Do
Cylicocyclus nassatus	Do
Cylicodontophorus bicoronatus	Do
Cylicodontophorus euproctus	Do
Cylicostephanus asymetricus	Do
Cylicostephanus calicatus	Do
Cylicostephanus longibursatus	Do
Cylicostephanus minutus	Do
Gyalocephalus capitatus	Do
Oxyuris equi	Do
Poteriostomum imparidentatum	Do
Probstmayria vivipara	Do
Strongylus edentatus	Do
Strongylus equinus	Do
Strongylus vulgaris	Do
Triodontophorus brevicauda	Do
Triodontophorus serratus	Do
Tapeworm	
Anoplocephala perfoliata	Do

Plant Pathology

Virus Disease of Papaya

The papaya disease, first reported last year, has been shown to be due to a virus. Juice inoculations from diseased plants to the foliage of healthy papaya plants, using carborundum as abrasive, have resulted in more than 75-percent transmission. (Parris)

Bean Rust

In the 1938 annual report from this station it was stated that differences in the susceptibility of certain bean varieties, as compared with the findings of other investigators, led to the belief that the physiological form of rust present in Hawaii was distinct from form No. 1 or No. 2.

Early in 1939, field observations on Oahu indicated that many introduced varieties, previously immune or only very slightly susceptible to rust, were no longer immune, and rust appeared in greater or lesser abundance on both foliage and pods. Greenhouse inoculations have confirmed these observations and a different form of rust is possibly now present in the Territory. The four varieties recommended to growers as rust resistant have remained unaffected by this new strain. (Parris, Welch)

Virus of Yellow Spot of Pineapple on Tomato

Investigations have shown that the previously reported "ringspot" disease of tomato is caused by the virus of yellow spot of pineapple. The virus has been mechanically transmitted from diseased tomato to healthy tomato, potato, and *Emilia sonchifolia*, from diseased *Emilia* to healthy *Emilia*, and from diseased potato to healthy potato and tomato. The virus has also been transmitted from tomato to tomato and potato and from potato to tomato by grafting.

All available evidence points to the belief that the virus of yellow spot of pineapple is identical with the virus of spotted wilt, but physical properties have not yet been compared. (Parris)

Nematodes on Potatoes

The nematode population in the soil varies considerably within a single row of potatoes. A number of hills were harvested singly and

the tubers examined for the presence of galls due to *Heterodera marioni* (Cornu) Goodey. Soil from around the tubers was collected at the same time and cowpeas planted therein to serve as indicator plants. The cowpeas were pulled 30 days after planting and the number of galls on the roots counted. Results show that there is a positive correlation between the severity of galling of tubers and the number of nematodes in the soil. Where infection on tubers was "severe," the average number of galls per cowpea plant was 228; cowpea roots grown in soil from hills which showed "mild" infection and no infection averaged 111 and 75 galls, respectively, per plant. Plants growing in adjacent hills commonly showed wide differences in nematode infection and gall count.

Data were also gathered from 169 hills, selected at random, on the relation of the size of the potato tuber to the severity of nematode infection. The results are summarized in table 9. Large tubers seem to be more liable to attack than smaller tubers. However, the type of infection on large tubers was more often "mild" than "severe," while the reverse was true for smaller tubers. (Parris, Kikuta)

TABLE 9.—Relation of size of potato tuber (variety Bliss Triumph) to severity of infection by *Heterodera marioni*, 90 days after planting

Size of tuber	Total number of tubers examined	Percentage of tubers		
		Healthy	Mild infection	Severe infection
Large	86	70	19	11
Medium	523	78	9	13
Small	436	76	4	20

Early Blight of Potatoes (Alternaria solani)

The fungicidal efficiency of 4-4-50 bordeaux mixtures made with local stone lime, local slaked lime, and imported stone lime in the control of *A. solani* was compared with that of 4-2-50 bordeaux made with local stone lime, 4-5$\frac{1}{3}$-50 bordeaux made with slaked lime, Copper Hydro "40," Cuprocide "50," and Coposil. The last-named commercial product, tried previously in 1937-38 with little or no benefit, was again supplied at the rate of 2 pounds per 100 gallons,

the Copper Hydro "40" at 8 pounds per 100 gallons, and the Cuprocide "54" at 3 pounds per 100 gallons.

Plots were harvested at intervals of 70, 80, and 90 days after planting, and the mean yields per spray treatment are presented in table 10.

TABLE 10.—Effect of spray treatments on yield of potatoes at intervals of 70, 80, and 90 days after planting

Spray treatment	Mean yield per 100 plants[1]		
	70 days	80 days	90 days
	Pounds	*Pounds*	*Pounds*
A. 4-4-50 bordeaux, imported stone lime	103	118	134
B. 4-4-50 bordeaux, local stone lime	96	111	128
C. 4-4-50 bordeaux, local slaked lime	108	121	130
D. 4-5½-50 bordeaux, local slaked lime	113	116	132
E. 4-2-50 bordeaux, local stone lime	99	110	124
F. Coposil	113	113	134
G. Copper Hydro "40"	102	111	129
H. Cuprocide "54"	109	126	132
I. Check	105	107	120

[1]Standard error of means ± 6.

From table 10 a few points are outstanding:

(1) At 70 days, no spray treatment gave a significantly higher yield than the unsprayed check. Treatments C and H were both better than B, and treatments D and F better than either B or E.

(2) At 80 days, treatments C and H were better than the check, and H was also superior to B, E, F, and G.

(3) At 90 days, treatment H was still better than check, as were treatments A, D, and F.

From field observations, the best control of *A. solani* was obtained with 4-2-50 bordeaux, while Coposil and Copper Hydro "40" gave little or no control. Why 4-2-50 sprayed plots should yield so poorly is not clear, although the use of local stone lime may be partly

the cause, evidenced by the fact that spraying with 4-4-50 made with stone lime also resulted in poor yields. The latter spray gave almost as good control of *A. solani* as 4-2-50 and about the same degree of control as the other bordeaux sprays. More research will have to be carried out before an explanation can be given of the increase in yield of check plots at 90 over 70 and 80 days respectively; the plants were badly diseased at 70 days and appeared to be dead at 80 days. The yields of plants sprayed with Coposil and Copper Hydro "40" also illustrate this anomaly. Yields of plots sprayed with Cuprocide "54" compared very favorably with the best yields obtained at 70, 80, and 90 days. (Parris, Kikuta)

Toxicity of Bordeaux

Despite careful and renewed spraying with freshly prepared bordeaux (4-4-50), *Alternaria solani* causes appreciable destruction of potato foliage. Whether this may be due to a physical breakdown of the copper-lime compound under the high temperature-humidity climatic conditions of Hawaii is the subject of laboratory investigation at present.

A number of substitutes for bordeaux have been developed in recent years, many of them relatively useless as fungicides in the field in Hawaii. Field observations are being checked with laboratory studies, using not only the above named pathogene but also *A. brassicae* from cabbage and *Colletotrichum glocosporioides* from papaya.

Findings to date indicate that the following factors are of importance in these investigations: type of spore used, age of spores, number of spores per drop of water, and age of fungicide after preparation. For species of *Alternaria*, best germination is achieved with 3- to 5-day-old spores from culture on potato dextrose agar. *C. glocosporioides* grows best on slices of papaya, the host plant.

While germination of *Colletotrichum* can be completely inhibited by 4-4-50 bordeaux, the same cannot be said of the muriform spore of *Alternaria*. In water, *Alternaria* spores commonly produce 3 to 5 germ tubes, and in cabbage extract *A. brassicae* may produce as high as 8 germ tubes per spore. Placed on slides previously sprayed with bordeaux, at least one and sometimes more germ tubes are produced by a small percentage of the spores. These germ tubes may or may not be retarded in growth as compared with growth in water. (Kikuta)

Damping-off Control

A number of organisms cause damping-off of vegetable and ornamental seedlings in Hawaii, but species of *Pythium* and *Rhizoctonia* are the worst offenders. Preliminary studies with semesan and cuprous oxide, applied to the surface of seeds before planting in artificially infested soil, have demonstrated that there are real differences in damping-off control by these chemicals and also in their effect on preventing or delaying seed germination. The following chemicals are recommended for Hawaiian climatic conditions:

Semesan. Use on cabbage, cucumber, pumpkin, radish, squash, and watermelon.

Cuprous oxide (red copper oxide). Use on celery, eggplant, lettuce, and tomato.

Semesan or cuprous oxide. Use on beets and carrots. (Matsuura,[1] Parris)

Miscellaneous Plant Diseases

In table 11 is given a list of fungus diseases noted in the Hawaiian Islands during the past year but not discussed in this report. (Parris)

[1] Graduate student in plant pathology.

TABLE 11.—Miscellaneous plant diseases noted in the Hawaiian Islands, July 1938 to June 1939

Disease		Host	
Causal agent	Common name	Scientific name	Common name
Alternaria sp. (*cucumerinum*?)[1]	Leaf spot	*Cucumis sativus*	Cucumber
Bremia lactucae[1]	Downy mildew	*Lactuca sativa*	Lettuce
Colletotrichum sp. (*papayae*?)[1]	Petiole spot	*Carica papaya*	Papaya
Didymella (?) sp.[1]	do	do	do
Glocosporium sp.	Fruit rot	*Anacardium occidentale*	Cashew
Phoma lingam	Leaf spot	*Brassica campestris*	Cabbage
Phyllosticta sp.[1]	do	*Carica papaya*	Papaya
Phyllosticta sp. (*richardiae*?)[1]	do	*Zantedeschia aethiopica*	Calla lily
Phytophthora infestans	Late blight	*Lycopersicon esculentum*	Tomato
Phytophthora sp. (*parasitica*?)	Bud and fruit rot	*Cocos nucifera*	Coconut
Puccinia antirrhini[1]	Rust	*Antirrhinum* sp.	Snapdragon
Pythium sp.	Root rot	*Zingiber officinale*	Ginger
Pythium sp.	do	*Carica papaya*	Papaya
Rhizoctonia sp.[1]	do	*Callistephus* sp.	Aster
Rhizoctonia sp.[1]	do	*Vigna sinensis*	Cowpea
Septoria sp. (*phlogis*?)[1]	Leaf spot	*Phlox* sp.	Phlox

[1]First record for Hawaii.

Plant Physiology

Germination of Sugarcane Buds

During the year experiments have been conducted to determine factors affecting bud and root development and to account for irregularities in germination apparently due to time of planting. The data so far secured indicate that influencing factors include the following: Soil temperature, which depends both on season and depth of planting; soil moisture; soil aeration; number and position of buds on planting material; age of seed piece; and carbohydrate and nitrogen reserves of seed piece.

The relative germination of sugarcane buds at three locations and with planting material of three ages was studied. Average maximum temperatures at the three sites were 73.8°, 85.6°, and 91.6° F. Stalks of 12-month-old cane were divided into seed pieces with three buds each, the topmost third of the stalk constituting planting material from 1 to 4 months old, the middle pieces ranging from 5 to 8 months old, and the basal pieces from 9 to 12 months old.

Table 12 shows the degree of emergence and the average time required, number of roots, and length of shoots.

That the temperature of the soil is an important factor in both germination and development is clearly evident, and it appears that the irregular behavior of planting material can be explained, in large part, on the basis of soil temperature as influenced by season and depth of planting.

Observations during the course of the experimental work indicated that when soil flats were not watered regularly, no roots were formed. Overirrigation or poor drainage, on the other hand, caused rotting of roots. A soil which puddled gave poorer germination than a more granular soil which remained well aerated.

To determine the effect of internal factors on germination, a series of tests was conducted in which soil temperature and moisture were uniformly favorable, the variable factors being planting position of the seed buds, number of buds to the seed piece, and age of planting material. As a result of this series, several generalizations may be made: (1) Single-bud seed pieces show better germination than

TABLE 12.—Experimental data on effects of soil temperature and age of planting material on sugarcane germination and development

Age of planting material	Average maximum soil temperature	Number of seed pieces planted	Emergence	Average time of emergence	Average number of cane roots	Average length of shoots
Months	*Degrees F.*		*Percent*	*Days*		*Centimeters*
	91.6	30	93.3	10.3	24.9	49.0
1-4	85.6	36	88.9	12.7	19.9	41.5
	73.8	31	50.5	20.4	28.5	17.0
	91.6	30	74.4	13.5	14.5	30.9
5-8	85.6	34	64.7	12.8	12.2	25.1
	73.8	30	31.8	21.9	5.1	8.6
	91.6	30	77.7	13.8	38.5	39.3
9-12	85.6	35	66.6	14.2	34.2	25.2
	73.8	31	45.2	24.2	20.0	9.3

longer seed pieces; (2) planting multiple-bud pieces with buds on the side is superior to planting with terminal buds up or down; (3) the terminal bud exerts an inhibiting influence on the basal bud; (4) buds, whether terminal or not, if planted on the upper side of the seed cane exert an inhibiting influence on the lower buds; and (5) the young seed pieces germinate better than the older pieces. (Clements)

Grass Seed Germination

In order to improve germination, many different treatments of chemical and mechanical nature were applied to seeds of 31 species of grasses which had been stored for varying periods up to 13 months. Germination counts were made every 7 days for a period of 28 days, and the percentage of germination was determined on the basis of total number of fertile seeds in the sample. Most of the seeds benefited from treatment, the various species responding, however, to different treatments. A few species do not require treatment; others do not improve in germination with any of the treatments under test. In some cases the problem of low fertility is more important than that of germination. The number of treatments and species involved in the experimental work makes conclusions impossible as yet; the problem was set up on this wide scale in an attempt to bring to light some of the underlying causes of dormancy in seeds. (Clements, Akamine)

Arsenic Toxicity to Plants

Two plants, Sudan grass (*Sorghum vulgare sudanense*) and bush bean (*Phaseolus vulgaris* var. *humulis*) were grown in water cultures containing known concentrations of arsenic introduced as sodium arsenite, ranging from zero to the previously ascertained toxic concentration. Observations indicated that the arsenic caused injury to the roots, resulting in interference with the plants' uptake of water. This is reflected by wilting followed by death of leaf tips and margins or, in higher concentrations, of the entire leaves. Growth is reduced progressively as the arsenic concentrations increase, and arsenic is found in the plants in concentrations roughly proportional to the concentrations of arsenic in the solutions. Plant parts contained arsenic in decreasing order as follows: Sudan grass—node, leaf, sucker, internode, and inflorescence; bush bean—leaf, stem and petiole, and fruit.

Both plants accumulate arsenic in excess of the legal tolerance limit when grown in concentrations of 1 part per million or more, but the actually lethal concentrations vary widely for the two plants—3 parts per million for the bean and 18 parts per million for Sudan grass. (Clements, Machlis, Heggeness)

Poultry Husbandry

Vaccination of Day-old Chicks for Control of Fowl Pox

Day-old Single Comb White Leghorn chicks were separated into three groups of 78 chicks each. Chicks in lot 1 were vaccinated in the web of the wing by the "stick" method and in lot 2 in the thigh by the "follicle" method; lot 3 was used as a check.

At the end of the fourth week fowl pox was introduced by placing infected chicks in all pens. Every chick in the check pen (not vaccinated) showed lesions by the sixth week. No lesions appeared in either of the vaccinated lots at that time.

It is evident, however, that if any immunity had been actually established in lot 2, it was only temporary, for at 6 months these pullets, when again exposed to fowl pox, showed 100 percent infection. Lots 1 and 3 at the same time appeared completely immune, lot 3 having become immune through natural infection.

Growth curves appear to indicate that pullets which were naturally infected with fowl pox at 4 weeks of age were temporarily retarded in growth, and at 6 months had not overtaken the two vaccinated lots. The weights of pullets at 6 months for lots 1, 2, and 3 were 3.6 pounds, 3.75 pounds, and 3.2 pounds, respectively. (Bice)

Control of Coccidiosis in Wire-floored Batteries and Houses

Data obtained over a 3-year period, with 13,000 chicks in wire-floored batteries and growing units, indicate that coccidiosis can be controlled. During this period, coccidiosis appeared in only one group of 50 cockerels, after they had been moved from the chick batteries at 6 weeks of age.

Several commercial poultrymen have adopted this method of rearing baby chicks and report very satisfactory results. Not only has coccidiosis been controlled, but the mortality in many cases has been reduced from 25 percent to less than 5 percent during the first 6 weeks of brooding. (Bice)

Feed and Growth Studies on New Hampshire Chickens

Feed and growth records from one day through the twenty-fourth week were obtained on New Hampshire chickens for the

purpose of serving as a guide to the many poultrymen who are interested in this breed.

The total feed consumed per bird was 36.1 pounds for the males and 36.2 pounds for the females. Since the males were much heavier than the females at 24 weeks (6.25 and 4.5 pounds, respectively) they are shown to be more efficient flesh producers. To produce a pound of live weight required 5.77 pounds of feed for males, 8.04 pounds for females.

In comparing New Hampshires with White Leghorns, no difference in rate of gain was found to the end of the seventh week. Both varieties averaged 1.3 pounds at that age. Later gains were more rapid and produced more economically with the New Hampshires than with the White Leghorns.

The study indicates that the new Hampshires make satisfactory broilers, fryers, and roasters. (Bice)

Egg Production of Hybrid Japanese Shamo Game Pullets

Studies of crossbred poultry reported last year indicated the superiority in respect to hatchability and rate of growth of hybrids from matings of Japanese Shamo Game males with Barred Plymouth Rock, Rhode Island Red, and Single Comb White Leghorn females over pullets from purebred parental matings.

Sixty hybrid females and sixty purebred Single Comb White Leghorn females in their first year of lay were compared on the basis of egg production. The duration of the test was 9 months, during which time the birds were confined in hen batteries.

The sixty hybrid pullets averaged 103.63 eggs with an average egg weight of 22.11 ounces per dozen. In the purebred group the sixty pullets had an average of 149.7 eggs, and an average egg weight of 22 ounces per dozen. The difference in egg production indicates rather clearly the superiority of the purebred Single Comb White Leghorns over the hybrid offspring of the Japanese Shamo Game mated with the Leghorns.

This result is in agreement with other reports where high-producing strains crossed with a low-producing strain have produced hybrid offspring intermediate in laying capacity. (Bice)

Breeding of Poultry in Confinement

A comparative study of breeding birds in confinement and on the ground has been in progress during the past year. High land values, together with a rather intensive system of raising poultry, have brought demands for data relative to the performance of breeding stock in close confinement.

Twelve pedigreed breeding pens, each containing ten hens and one male, were mated; six lots were confined on wire-floored houses, and six were given access to a breeder house and to the ground.

Results of this experiment are summarized in table 13.

TABLE 13.—Fertility and hatchability as influenced by confinement of birds on wire floors

Variety	Number of eggs set	Fertile eggs	Number of vigorous chicks	Hatchability	
				Total eggs	Fertile eggs
		Percent		*Percent*	*Percent*
Single Comb White Leghorns in confinement	1390	89.8	776	55.8	62.1
Single Comb White Leghorns on ground	1824	73.4	867	47.5	64.7
Barred Plymouth Rocks in confinement	311	77.2	162	52.1	67.5
Barred Plymouth Rocks on ground	346	78.0	176	50.9	65.2

Differences in fertility and hatchability between the birds on the ground and those entirely on wire floors were not sufficient to indicate superiority of either method. It is apparent that breeders can be kept in complete confinement successfully in the Territory. (Bice)

Utilization of Urea Nitrogen

Experiments both in the United States and in Europe have shown that ruminants can utilize simple nitrogenous compounds as a protein supplement, presumably through bacterial synthesis of protein within the rumen. A controlled experiment was undertaken to determine whether a similar process occurred to any measurable extent

with poultry. Definite protein starvation characterized by retarded growth was observed when urea was fed as the supplement to a low-protein ration. Apparently, the digestive tracts of poultry are not capable of synthesizing protein from simple nitrogenous compounds such as urea by bacterial action. (Bice, Dean)

Salt Balance of Molasses Feed

Excessive amounts of molasses in rations give rise to diuretic effects. In order to determine the amount of molasses which can be added to feeds without causing these effects, a preliminary experiment was conducted with salt mixtures in synthetic diets. Excessive amounts of either sodium or potassium chloride caused diuretic effects. (Bice, Dean)

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(Pierson)

Branch Stations and Farms

Kona Branch Station

This branch station, at an elevation of 1,500 feet, now has an area of 12.16 acres. During the year the coffee investigations were increased by the installation of several more fertilizer experiments in orchards of cooperators. The experiments have yielded valuable results, and numerous meetings with farmers have resulted. Experiments with macadamia, citrus, avocado, mango, taro, and cattle feeding are also being followed with interest. This is especially true of the macadamia propagation and nursery investigations. Numerous inquiries and visits have been received in connection with this work.

During the year, 2,380 grafted trees of 60 selected varieties of macadamia were grown, packed, and set in variety tests on Hawaii, Maui, and Oahu. In addition, 400 seedlings were grafted, and these will be available for transplanting to field tests during the coming year. Approximately 1,100 cuttings of avocado graftwood from five of the best avocado trees, 1,000 taro plants, 60 sweetpotato slips, and 30 breadfruit root cuttings have been distributed to farmers and home owners throughout the islands. (Pahau)

Haleakala Branch Station

This branch station, located 2 miles above Makawao on the slopes of Haleakala, at an elevation of about 2,200 feet, consists of 38.66 acres. One-third or slightly over 10 acres is cut off by a large gulch. This area is planted to grasses, including aggressive, tropical, and temperate species, cross-fenced into four 2½-acre paddocks. The west portion is devoted to Napier and Napier strain grazing trials, palatability trials of selected species, and grass gardens. Approximately 218 species and subspecies of world-wide introduction are represented in the grass gardens. Seventeen head of steers are carried on grazing trials.

Horticulture plantings include 208 macadamia trees, 60 litchi trees, and small fruits.

A mule barn has been erected, cattle scales and a holding pen constructed, the foreman's home enlarged, a three-car garage rebuilt,

the superintendent's house remodeled, and all new construction given a coat of stain. Many new cross fences for cattle grazing have been built and all boundary fences rebuilt. (Murphy)

Poamoho Farm

This farm, between Wahiawa and Waialua, is typical of much of the land on the Island of Oahu. It was acquired September 1, 1937, and consists of 30.8 acres; an additional area of 4.3 acres is leased. An irrigation system, implement shed, and combination greenhouse and plant propagation house were completed the first year. During the past year an attractive residence was built for the farm foreman, and the grounds have been landscaped.

Experimental work during the year was limited to investigations in horticulture and agronomy. Fifteen acres were devoted to potato investigations, 10 acres to papayas, 5 acres to macadamia trees, and 5 acres to various grasses and legumes. (McDougal)

Fiscal Statement—1938-1939

RECEIPTS

	Federal Funds—Agricultural Adjustment Administration				
	Liver fluke	Truck crops	Feeds	Fruits and nuts	Poultry
Received from the Treasury of the United States					
Balance from 1938-39	$ 1,486.51	$ 954.06	$ 2,782.09	$ 762.65	$ 802.92
Receipts from Territorial funds					
Receipts from sales					
Total receipts	$ 1,486.51	$ 954.06	$ 2,782.09	$ 762.65	$ 802.92

DISBURSEMENTS

Personal services	$ 997.94	$ 318.85	$ 704.83	$ 130.95	$ 177.00
Supplies and materials	213.57	8.82	637.13	7.85	598.05
Communication service					
Travel expenses					
Transportation of things		3.02		.48	3.15
Printing and publications					
Heat, light, water, and power	8.35				
Rents			120.00		
Contingent expenses	93.95				24.72
Equipment	172.70	623.37	1,320.13	623.37	
Buildings and land					
Total disbursements	$ 1,486.51	$ 954.06	$ 2,782.09	$ 762.65	$ 802.92

FISCAL STATEMENT—1938-1939 (Continued)

RECEIPTS

	Federal Acts				Territorial			
	Hatch	Adams	Purnell	Bankhead-Jones	Bankhead-Jones Offset	Special	Coffee	Total
Received from the Treasury of the United States	$15,000.00	$15,000.00	$25,000.00	$8,038.10				$ 63,038.10
Balance from 1938-39							$ 704.01	7,492.24
Receipts from Territorial funds					$8,038.10	$ 83,617.39	2,500.00	94,155.49
Receipts from sales						21,755.01		21,755.01
Total receipts	$15,000.00	$15,000.00	$25,000.00	$8,038.10	$8,038.10	$105,372.40	$3,204.01	$186,440.84

DISBURSEMENTS

Personal services	$13,084.35	$12,820.60	$24,147.16	$7,315.00	$7,958.79	$ 62,068.01	$2,658.35	$132,381.83
Supplies and materials	354.64	836.85	543.96	224.60	69.05	16,275.12	414.91	20,184.56
Communication service					5.25	721.74		726.99
Travel expenses			137.85			1,890.90		2,028.75
Transportation of things	21.60	.88				425.93		455.06
Printing and publications	829.89					3,063.54		3,893.43
Heat, light, water and power			12.75			3,560.45		3,581.55
Rents								120.00
Contingent expenses	132.00	30.50		5.00	5.00	7,261.39		7,552.56
Equipment	577.52	1,311.17	58.28	493.50		3,436.37	130.75	8,747.16
Buildings and land			100.00			6,668.95		6,768.95
Total disbursements	$15,000.00	$15,000.00	$25,000.00	$8,038.10	$8,038.10	$105,372.40	$3,204.01	$186,440.84